

# School Science

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## THE VALUE OF FIELD AND HERBARIUM WORK.\*

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In introducing the discussion of this subject is it not well to ask ourselves what are the main purposes of a course in high school botany or biology?

It will then be possible to consider the best ways to accomplish these ends, and whether we, as teachers, are giving the proper proportion of time to those lines of work which are likely to insure the best results.

Since, on the average, not more than 1 to 2 per cent of high school students go to college, it goes without saying that the sole purpose of a high school botany course is not merely to get the pupil over a certain amount of work that will fulfill the entrance requirements of botany at some college, and thus secure for him one credit.

Certainly the high school course in botany is not to prepare specialists, for probably not more than one student in 500 who takes elementary botany ever becomes a specialist in any branch of the science.

There are, however, each year a large number of pupils who come up to the first or second year of their high school courses knowing almost nothing of the great plant kingdom.

In the Central High School of Toledo there are, this present semester, 250 such freshmen taking elementary botany (about 18 per cent of the total enrollment of the school). In other schools the per cent is probably about the same.

The question of vital interest to us, therefore, as teachers of

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botany, is, how can we best prepare these pupils so that they shall have the most thorough training and the most useful knowledge of the great plant world around them?

What subject can be made more fascinating to the pupil than botany if presented to him in a way that he can properly comprehend it? If the majority of pupils in a school is not interested in its botany, it must be due to an emphasis being laid on the less important phases of the subject, or to the manner in which the work is presented. I can not conceive of botany being a "dry" subject to the intelligent pupil if properly taught.

How can the three essentials of botany, viz., the field work, the indoor laboratory work, the textbook and assigned reading, be combined in the right proportions to give to the pupil not only the best training and the most desirable knowledge of plant life, but also to give him an interest and a love for such study that will go with him long after his school days are over?

With all due regard for the value of well-chosen indoor laboratory work, I maintain that nothing in elementary botany can replace in importance the value of learning to see and to think in the field. The laboratory of the chemist is almost wholly indoors; not so the laboratory of the botanist. No indoor laboratory work can replace wholly the study in Nature's own laboratory—the great plant world out of doors.

"Eyes have they, but they see not," is true, not only of the majority of pupils beginning the study of botany and zoölogy, but it is also true, I fear, of far too many of our young people after the completion of their high school courses in these subjects. They are taught to dissect, to analyze, to perform certain experiments, but not taught to see or to think about the most common forms of plant or animal life in their out-of-doors surroundings.

Is it not true, as one successful teacher in botany has suggested, that in too many high schools an attempt is made to introduce botany from the standpoint of the college? The pupil is expected to plunge into indoor laboratory study of the structures of plants that he knows nothing about—or, in too many cases, cares nothing about—or to attack advanced problems before he has

been given an opportunity to learn even the most simple things about plants.

The future life of 99 per cent of our high school pupils who study botany or zoölogy is to be spent outside the laboratory. How can they best be trained to think about the forms of life with which they will almost daily come in contact in future years? I know of no better training for this than well-directed work in the field.

By well-directed work in the field I do not mean mere excursions to the woods or elsewhere, where boys and girls can go with their teachers to get out of doors and merely have a good time, possibly seeing and learning a few things incidentally—or accidentally. A mere excursion means a good time and no arduous labor for either teacher or pupils; but it does not bring results.

Real laboratory work in the field means a great amount of work for the teacher who loves his subject and is anxious to get the best results from his high school friends in his classes. It also means no small amount of work for the pupils, who have to take careful notes in the field, write them up in good English for their laboratory books, and possibly to rewrite, or at least to revise, them after the first correction. This all means hard work and plenty of it for both pupils and teacher, but I believe that it pays, and pays well.

To avoid generalities I shall suggest in the third person a few things that have come in my own experience and attempts to get definite, desirable results from field work.

To a teacher living in a town or village with woods, an abundance of wild flowers and various kinds of plants' societies and ecological conditions near at hand, the problem of finding and doing field work is easy of solution. Let us consider a much more difficult case.

A person teaching in a city high school has, for illustration, 150 pupils in botany, whom he instructs in five or six sections. Could one ask for a more difficult problem in this line than getting so many active young people out for successful field work, especially in a city where it is sometimes stated that there are

no suitable places for field work within a radius of miles?

Let us further suppose that the student will be marked 0 for every recitation period that he is absent from his other work. Moreover, only one-half day each semester is allowed by the principal who fails to appreciate the importance of field work. Each teacher may have a different solution for his own school, but a plan that has proven successful on several occasions with large classes will be outlined.

Before stating this plan let us first look to the preparations for such a field trip. For the first trip of the season, let us go to the conservatory of one of the public parks or to a locality where we can study a dozen or more of our common evergreens. There is much to be learned from either of these trips, and they naturally suggest themselves as among the first of the season before the arrival of the spring wildflowers.

The teacher goes carefully in advance once or twice—better twice—over the ground to be covered by the class. He thus forms his definite plans of what he wants his classes to observe and to study, and how best to direct them to get desired results.

The next step is to print on an Edison mimeograph a sheet, with which every member of the class is to be supplied, calling attention to the purpose of the trip and giving such definite directions and suggestions as may seem necessary. To prepare 150 such sheets means a solid evening's work, and some may prefer to dictate such directions or to write them on the blackboard, requiring each pupil to copy same in his field notebook. The mimeograph sheets are time-saving to the pupils, and also have many advantages.

When each pupil has his "direction and suggestion" sheet and knows how to go to work for himself, forty to fifty pupils can be handled on a single trip, although half that number is preferable. The printed sheets do away with the "sheep and shepherd" idea, where the teacher leads or drives his flock of pupils; or with the so-called "lecture plan," where a well-intending instructor attempts to gather about him his flock and explain to them the points of interest as he sees them. To keep together thus in the field forty to fifty active young people and to hold their atten-

tion one must be an unusually clever general and have a stentorian voice. Moreover, by this plan of procedure the pupils are likely to be told much that they ought to find out for themselves.

Now, how has it been possible to get all the desired number out into the field at one time without missing their other work?

On the day previous to the trip the one or two sections that are to go are notified that on the following day they can bring to the laboratory such books as they may need in the preparation of any of their lessons—that the period is to be theirs for quiet study and that at the close of school they will be given a field trip.

In this way the field trip takes very little extra time of the pupils and does not make it necessary for them to miss other classes. If the field trip is to be given some distance from the school building, the pupils are allowed to choose their own way of getting there. Some go by street car part of the way, some of the boys ride their wheels, some half-day session pupils go directly from their own homes instead of returning to the school building in the afternoon.

Each pupil has his own sheet, and as soon as he arrives he goes to work by himself or joins a small group with whom he prefers to work.

By a certain time all are busy working and taking notes. It then remains for the instructor to pass around among the different groups to see how their work is progressing, giving such encouragement and suggestions as he deems best.

The next laboratory or recitation period the reports of various members of the class are read and discussed. Many errors in observations or conclusions may be brought to light, but it also gives abundant opportunities for calling attention to the best ways of working carefully and intelligently in the field. After the desired points of the trip have been carefully reviewed, and each pupil revises or rewrites his first account, this is finally copied into his laboratory book as a special laboratory exercise.

As soon as the flower season has arrived considerable interest can be added to the field work by the keeping of a "flower calendar." The flower calendar is kept on the blackboard or in some

other conspicuous place, where the pupils can easily refer to it. The scientific names of the flowers are recorded, together with the date when first brought into the class and the names of the pupils first bringing them in. The public recognition thus given to the active, energetic field workers encourages a healthy, good-natured rivalry between the different sections or the different individuals.

One specimen of each kind of plant is sufficient for a credit, and this does not render necessary the ruthless destruction of a large number of plants.

In order that each pupil may know when he has secured a new—i. e., unrecorded—specimen, it is necessary for him to have a knowledge of the specimens already reported, and thus there is an incentive to become familiar with as large a number of plants as possible. There is little difficulty in getting a list of over 100 species of wild flowering plants during the spring and early summer, which gives the pupil a fair introduction to the wildflowers of his vicinity.

Another most useful and interesting line of field work is a study of our common trees. Of the public at large probably not one in 500 can name with certainty a dozen of the common trees around them. In smaller and larger places alike, trees are easily accessible for field study. There are few places, indeed, outside of the largest cities where it is not possible to study at least forty different kinds of trees within a half-mile of the high school building.

A thorough knowledge of these puts the pupil "in line" to learn many more, and it has a strong tendency to arouse an interest in his immediate surroundings and to teach him to observe. Trees being so easily accessible, it is possible to take out each section occasionally during their regular laboratory periods to make a study of a definite number of trees and to return them to the building before the next recitation period.

It is, of course, necessary to review these trees a great many times before they are fixed indelibly in the pupil's mind. After a certain trip of this kind last year I found that the pupils, without any previous warning, could give the names and indentifying characteristics of over thirty-five different kinds of trees

growing within a quarter of a mile from the high school building. By another trip of equal length in another direction the list could easily have been increased to fifty.

Is it not worth while that the pupils should know the names and identifying characteristics and the economic importance of the trees that they see so often, rather than to spend all of their time in studying indoors? This certainly is most useful, valuable knowledge and can be made a very valuable training.

If the pupil is to make any practical use of his botanical knowledge out of doors, should he not be instructed in such lines while still in high school?

In regard to the herbarium, I believe that every high school should have a school herbarium containing representatives of as large a number as possible of the local flora. That this can be judiciously used by both instructor and pupils there can be no doubt. Whether it is best to require each pupil to make an herbarium for himself is a very different question.

The science and art of preserving and mounting flowers, leaves and other interesting parts of the flowering plants is valuable to the pupil, just the same as is a knowledge of making mounts and staining sections for the study of the lower forms; but the consideration of the plants thus destroyed must not be overlooked.

If the 250 pupils taking elementary botany in the Toledo High School annually were required to present each an herbarium of forty pressed specimens, it is not improbable that the loss of the 10,000 plants thus used each year would make, in a few years, a notable decrease in the abundance of the wild flowers in the vicinity of Toledo.

In rural districts the conditions are different, but in the larger places, where the flowers near at hand have been so largely exterminated, it would seem a great mistake to require the pupils to hasten this unfortunate condition by making individual herbariums of the choicer wild herbaceous plants.

If field work on trees is to be undertaken, then an herbarium of pressed leaves, carefully identified, from twenty species of our common trees, might be valuable to the pupil, and at the

same time would not make the least appreciable difference to the trees themselves.

The preparation of leaf herbariums would give the pupil the knowledge of how to make an herbarium and how to "write up" each specimen carefully; it would consume a comparatively small amount of time, and, best of all, it would not hasten the extinction of any desirable plants.

If the pupils were encouraged to make *weed herbariums* I am not sure but that it might effect very desirable results, and at the same time teach the science and art of herbarium-making, as well as if choicer flowering plants were used.

A study of weeds can be made of great profit and interest in many ways; and requiring a weed herbarium of twenty specimens, all of which should be "written up," would do much to acquaint the pupil with some of the more common weeds and their undesirability, as well as to assist in their legitimate extinction.

By ecological studies in the field the most important knowledge of our desirable wild flowers could be obtained without their ruthless destruction. At the same time an opportunity is offered to impress upon the pupils that too many of our most interesting and most beautiful wildflowers are very rapidly disappearing, and that an effort to preserve them is now becoming necessary. Where can the sentiment against this destruction of Nature's most beautiful flowers be better instilled than in the coming generation of citizens now in our high schools?

Carefully selected and well developed field work is yet in its embryonic stages; something has been written about it; some progressive, thoughtful teachers have given us valuable bits from their own experiences in this work; but have its full possibilities and importance yet begun to be appreciated by the majority of teachers?

We know of no authority on this important subject. How can it be better developed and understood than by each member of just such progressive bodies of teachers as this contributing from his own experiences, or by taking part in the discussions as opportunity offers?

LABORATORIES OF THE MASSACHUSETTS STATE  
BOARD OF HEALTH AND THE METHODS OF  
ANALYSIS EMPLOYED THERE.\*

The samples of foods and drugs for analysis are collected by three State inspectors, among whom the entire State is divided in such manner that each inspector may have a fair portion of the ground to be covered. The samples collected are known by number only; the analyst himself has no inkling of the name of the dealer whose wares he is testing. The various operations of the analysis are performed under lock and key—the sample bottles are kept locked, the water baths are padlocked, etc.—a necessary precaution to enable the analyst to testify under oath that his analyses have in no wise been tampered with.

Only lately has the feeling become strong that proper food for human beings is, after all, a matter of some importance. years of patient research have been devoted to determining the very best fodder for cattle; but, as for human beings, what they eat has been regarded as a subject of comparatively slight importance.

Since 1882 Massachusetts has inspected foods. Today nearly every State has its food laws, but only about ten or twelve have the food analysts, whose work alone can furnish the basis for enforcing these laws. Certain cities, very few in number, support their own analysts. The work of these men, however, has been confined thus far solely to the inspection of milk.

The law of Massachusetts in regard to foods is very clearly stated: A food must be pure; it must contain no foreign substance which can in any way injure its quality. The addition to milk, for instance, of preservatives, such as formaldehyde and boric acid, is clearly an adulteration, because milk is a pure food of accurately fixed standard. The watering of milk is an equally culpable process, inasmuch as the quality of the milk deteriorates in the same proportion that the water is added.

A large number of our foods are not simple, natural products,

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\*From the report of the nineteenth meeting of the New England Association of Chemistry Teachers.

as milk, flour, etc., but are mixtures of compounds of greatly varying complexity. Jellies, jams and many manufactured products furnish an excellent illustration of this second class of food material. The law pertaining to this class of foodstuffs demands the same strict conformity to standards as in the case of the simpler foods. It would obviously be unwise, not to say unjust, to require a complete statement upon the label of the ingredients of every food and drug placed upon the market. Many drugs, indeed, are practically trade secrets, and any legal coercion making these secrets public would be manifestly unjust. But the law does require, and with eminent propriety, that no mixture or compound shall contain any foreign substance that can be positively and unquestionably injurious to the human body.

The fundamental principles upon which these food laws rest are definite and self-evident. A food, to be pure, must be sold for what it is. It must contain no ingredients harmful to the human system; and, moreover, it must contain no foreign substance which can possibly conceal inferior quality. The question of whether a given sample of food is pure or impure, unadulterated or adulterated, can be answered only by determining whether it does or does not conform to that food's particular legal standard. And legal standards for foods must naturally differ widely in the strictness of their requirements. Milk, a vital, natural food, has its own special and stringent requirements; but food mixtures, such as ketchup, etc., whose composition may properly vary considerably, are subjected to very much laxer legal restraint.

The moral effect upon manufacturers of the knowledge that their food and drug products are liable at any and every time to be examined by a competent board of State analysts must be very powerful. To be assured of the truth of this statement it is only necessary to call attention to the high quality of foodstuffs in the States of Massachusetts and New Hampshire, whose food laws are enforced with strictness, tempered with keen judgment.

The lay reader has little idea of the number of foreign substances which clever producers introduce into their wares in their

efforts to reap a larger profit. To merely mention this host of foreign material, which may at any time enter our inoffending stomachs, would frighten many a timid person; but, after all is said and done, it may be said on authority that these various, and at first sight alarming, adulterations are not commonly injurious to the human system.

A person in good health may eat just what he likes and run little danger of unpleasant consequences.

In the case of infants and invalids, however, an exception should be taken. An adulterant which may be wholly harmless to a healthy stomach may work serious injury to a delicate one. Grape-juice, for instance, which physicians often prescribe, is sometimes adulterated with salicylic acid, a substance harmful in the extreme in certain conditions of the body.

Milk is the most commonly adulterated of all foods. The addition of water and the removal of fat in the form of cream are the two most serious evils. The determination of the total solids by evaporation, in connection with the determination of fat by the Babcock centrifuge, tells clearly the story of watering and skimming. The Babcock fat determination is, briefly, as follows: A measured volume of the milk, treated with an equal volume of concentrated sulphuric acid, is whirled around with extreme rapidity, in a Babcock machine. After five minutes the centrifugal force has driven all of the fat, on account of its low specific gravity, into the slender graduated neck of the bottle, where the per cent of fat is read off directly.

With the help of two simple instruments, the lactometer and the lactoscope, the examination of milk for watering and skimming may be carried easily into the high school. The lactometer is simply a hydrometer adapted to milk. The Quevenne pattern includes also a thermometer and makes a very satisfactory instrument for the determination of specific gravity. The lactoscope gives a fair approximation to the percentage of fat in milk. The instrument consists of a graduated glass cylinder, within which is a spindle bearing certain black lines. A measured volume (4 c. c.) of milk is run in by means of a pipette; then sufficient water is added, with thorough mixing, to just allow the black

lines of the spindle to become visible. The height of the liquid, milk and water combined, is then read off upon the cylinder, giving at once the per cent of fat. The determination of the specific gravity should be made first, and should give a result between 1.027 and 1.033. An abnormally low specific gravity means either that the milk has been watered or that it is exceptionally rich in cream. Which of these cases is true is usually easily decided by the appearance of the milk. Skimmed milk will naturally yield a specific gravity abnormally high. Combined skimming and watering may offset each other and result in a specific gravity close to the normal. In both of these latter cases the estimation of fat by the lactoscope will complete the desired information.

In freezing cold weather it is not an easy matter to obtain a perfectly fair sample of milk for analysis. It is customary to pour the milk first into a can, and then back into the bottle again, before taking a sample, these two pourings affording a reasonable warranty of obtaining an average sample. But if the milk is partially frozen the ice which separates leaves the liquid portion correspondingly richer in fat. For this reason winter milk analyses are wont to be slightly overfavorable to the quality of the milk.

The question of milk has been treated thus fully because it seems very possible to introduce the examination of this food with little expense and great profit in a first-year course in chemistry. The procedure outlined, although involving no chemical changes, exhibits the fact that special apparatus is frequently called into play in operations upon such complex substances as foods. The ability to test milk, moreover, carries a valuable power directly into the homes, and may act as a public safeguard for at least this one vital food material.

Aniline dyes are used to some extent to conceal inferiority, and sometimes, in fact, to give the whole degree of color to a product. A sample of *crème de menthe*, for example, attracted attention because of the fact that its beautiful green color, which should have been produced by chlorophyll green, was in reality due to a coal-tar dye. The proof of this rested in a square of woolen cloth, which had been dyed a most rich and vivid green by

simply boiling with the crème de menthe. Wool fixes many coal-tar dyes by boiling alone. It may prove convenient, then, to have on hand some squares of woolen cloth (albatross cloth or nun's-veiling is excellent) with which to test suspected colors. Close by a bottle of limejuice with a wool square, dyed a brilliant orange; the interesting point here seemed to lie in the fact that so pale a solution, apparently, as the limejuice could produce so startling a color effect upon the cloth. Specific cases like these might easily be multiplied, but brevity requires that no more instances be given in the present report.

The literature of the subject is extended. The standard reference is an immense work by J. Koenig, entitled "*Chemie der Menschlichen Nahrungs-und Genuss-mittel*." (1889.) For the average teacher the best general work is undoubtedly, "*Select Methods on Food Analysis*" (1901), by Leffmann and Beam, published by Blakiston & Co., Philadelphia.

For single articles reference should be made to "Character and Extent of Food and Drug Adulteration in Massachusetts and the System of Inspection of the State Board of Health," by A. E. Leach, in the *Technology Quarterly* for March, 1900, and also to a valuable article on food methods in the "Reference Handbook of the Medical Sciences," by the same writer.

An interesting pamphlet, entitled "Reports Upon Food and Drug Inspection," may be obtained upon application to the public document room, room 333, State house, Boston. In the forty-eight pages of the report are clearly summarized the results of a year's (1902) food and drug inspection in Massachusetts. The report for 1903 will be issued the coming October or November. A pamphlet (forty-eight pages) covering the laws of Massachusetts relating to the inspection of foods and drugs may be obtained at room 141, State house. Two bulletins, Nos. 65 (price 10 cents) and 46 (price 5 cents), issued by the bureau of chemistry, United States Department of Agriculture, will be forwarded upon application to the superintendent of documents, Washington.

All of the work done by the department of water analysis is performed under an act "to protect the purity of inland waters

and to require consultation with the State Board of Health." The idea is, perhaps, prevalent that the Board of Health investigates simply the quality of the water used in the various cities and towns of the State. This is not correct. The Board of Health exercises a very general supervision over water systems. If a city or town desires to make a change in the existing conditions of water supply, that change can be made only in accordance with the second clause of the before-mentioned act, *i. e.*, in consultation with the State Board of Health.

Two laboratories are maintained by the State board—the one which the association visited in Boston and the Lawrence experiment station. The latter laboratory has for its special function the investigation of methods for purifying water and sewage. At Lawrence may be seen a sand filter, which, by exposing its five or more feet of thickness to the sewage water, effectually destroys the typhoid germs.

The work of the Boston laboratory may be divided into three classes. First, and most important, comes the regular examination of all public drinking supplies in the State. A town whose water supply has been found to be undefiled and little liable to pollution, and whose water has been customarily pure, would be required to send samples for analysis but two or three times a year. On the other hand, water which comes from a supply of uncertain purity, perhaps because of changing conditions, perhaps because of close proximity to a thickly settled district, is frequently examined as often as once a week. The second class of work of the water laboratory is to inspect projected water supplies in conjunction with the proposals from the city or town involved. The third department of the work of the laboratory is the inspection of sewage. Regular examinations are made of both sewage and effluent, or filtrate. The important object aimed at here is to determine the degree of purification effected. Acting upon these examinations as a basis, it is often possible to suggest methods of obtaining more efficient purification.

To enter into a detailed explanation of the methods of water analysis is manifestly beyond the scope of this report. Indeed, after the mechanical operations of the analysis are all performed

the correct interpretation of these results is a matter requiring no little experience and judgment. Briefly, the Board of Health examines water for turbidity, sediment, color, total solids, ash, free and albuminoid ammonia, chlorine, nitrates, nitrites, reducing power, hardness, iron and bacteria.

A brief summary of the methods employed follows in the order in which the examination actually proceeds:

I.—APPEARANCE. (a) *Turbidity*—Analyst looks through the water (1 to 2 litres) in front of a window and determines, by eye, qualitatively, the turbidity. (b) *Sediment*—Bottle is gently shaken and amount of material disturbed at bottom noted. (c) *Color*—Comparison with a set of standards, varying from white to yellow, and made by mixing solutions of potassium chloroplatinate and cobalt chloride in hydrochloric acid solution. (Hazen's color standards.)

II.—ODOR. (a) *Cold*—Taken the instant of unstopping. Certain fragile organisms, algae, decay, and their presence would be lost except for this first quick odor. (b) *Hot*—Heat in beaker, with watch-glass cover, almost to boiling; then with a quick movement partly uncover beaker and catch the first whiff.

III.—RESIDUE ON EVAPORATION.—(a) *Total*—100 to 200 cc. water evaporated to dryness upon a water bath. (b) *Loss on ignition*—A platinum dish rests upon a little triangle of platinum wire within a larger platinum dish. A powerful Erlenmeyer burner under the outer dish maintains the inner dish uniformly at dull redness. Organic material constitutes chief loss on ignition.

IV.—AMMONIA. (a) *Free*—Boil 500 cc. water, collect distillate in three Nessler tubes, 50 cc. each. (b) *Albuminoid*—Add solution of alkaline potassium permanganate (with potassium hydroxide). Boil, and collect ammonia set free in distillate. To distillates from (a) and (b), add 2 cc. Nessler's reagent and compare with standard color tubes.

V.—CHLORINE.—Add standard solution of silver nitrate, with potassium chromate as indicator. Reddish silver chromate gives satisfactory end point.

VI.—NITROGEN. (a) *Nitrates*—Clarify by shaking with aluminum hydroxide. Filter. Evaporate 10 cc. of filtrate to dryness, then add phenol sulphonic acid. Yellow picric acid formed. (b) *Nitrites*—Add acid solution of sulphanilic acid and *a*-naphthylamine hydrochlorate. Compare reddish color with standards.

VII.—OXYGEN CONSUMED. Boil 100 cc. water for five minutes with excess of acidified (sulphuric acid) solution of potassium permanganate. Discharge excess of permanganate with oxalic acid and titrate back to color.

VIII.—HARDNESS. Shake 50 cc. water with standard soap solution to permanent lather.

IX.—IRON. Dissolve residue of fixed solids in hydrochloric acid. Add potassium permanganate, then potassium sulphocyanide. Compare red color with standards.

X.—MICROSCOPIC EXAMINATION. Filter 250 cc. water through fine white sand. Organisms are retained on sand. Wash sand and organisms into test-tube. Shake well; decant organisms into small tube and make up to 5 cc. A slide is used holding 1 cc. and exposing 1,000 sq. mm. surface. Twenty positions each 1 sq. mm. in area are examined. The added result shows the number and variety of organisms per cc. of water.

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## THE FUNCTIONS OF NATURE STUDY AND WHAT IT CAN DO AS A PREPARATION FOR HIGH SCHOOL BIOLOGY.\*

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Nature study, like all new movements, has been severely criticised. These criticisms, however, are not so much attacks upon nature study, *per se*, as upon the method of teaching. The mistakes in teaching this subject arise either from the teacher's ignorance of the subject-matter or from a failure on her part or that of her critics to understand the true functions of nature work.

One of the most important functions of this work is to give a point of view, to develop an attitude of mind. Its aim is to develop the naturalist rather than the scientist. The facts gained are important for an intelligent understanding of nature, but

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they are not ends in themselves. One wishes the child to have an appreciation of all life. Through garden work, through field work, through simple experiments and through observations of the life-history and habits of different animals, the child should gain a wide experience. Each season should be more full of interest. The child makes new discoveries. He sees an ever-widening application of the laws governing life. For his contact with nature to have its proper value he must observe accurately, infer thoughtfully and question the universality of observation and inference.

Undoubtedly the child does observe to some extent undirected. But if one can judge anything from the average grown student's meager acquaintance with nature and his unreliable habits of work, the child needs special training along those lines. Another function of nature work is to lead the child to understand the relation of his life to the life about him. If this were understood, many foolish fears, much cruelty and superstition—which is the result of ignorance—would disappear. Nature study should awaken a love of nature, a joy in the outside world. The plants and animals would give the child more pleasure in their native haunts than under unnatural conditions. The woods would not be depleted of their flowers, the song-birds would not need the protection of the law.

If nature work is well taught, the child on entering the high school should have an awakened interest in biology. He would care for the material with which it deals. It will solve many questions that have arisen in his mind. He has already formed good habits of work; much time is thus saved. He brings to high school biology a large experience, gained directly and indirectly in the field and in the schoolroom. Biology is more real to him than it otherwise would be, for he has seen bird or flower or insect in its home. He can call to mind many illustrations of this or that point.

The time assigned for biology is limited. The teacher often has not time to give the wide field acquaintance with nature that the child needs. Many topics now taught in botany and zoölogy could be omitted if nature study were properly taught. Such topics as germination, development of buds, scars on twigs and the cause

of these scars, the effect of light, heat and moisture on plants, the life-history and habits of many of our common birds, insects and fish could easily be taught in the lower school. With these and other topics of like nature omitted from biology it would be possible to do more advanced and better work in the high school. Nature study ought not only to prepare the student better for the high school and the college, but it ought also to bring him into his life with a greater capacity for enjoying the natural, healthy pleasures in the life about him.

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#### SOMETHING NEW IN CHEMICAL LABORATORIES.

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Few, if any, of the secondary schools of the country are so well equipped in the line of chemical laboratories as is the West High School at Cleveland.

A radical departure from the old-time chemical desk with its many disadvantages, has been made and each pupil is provided with an individual desk. These desks are thirty inches high, forty-two inches wide and twenty-two inches deep, giving the student a working space, including sink, forty-two inches by twenty-two inches, nearly twice that allotted to each at the ordinary desk.

During a school day of five work periods the laboratory with its twenty-five desks easily accommodates 125 pupils.

Each of the five pupils who use the same desk during the day has a drawer with lock for his individual apparatus, such as  $A_1$ ,  $A_2$ ,  $A_3$ ,  $A_4$ ,  $A_5$ , while all five use the middle drawer, which contains apparatus of a general character. The drawers have partitions so that each piece of apparatus has its particular place.

The desk is equipped with a sink, a water faucet, a hood, a double gas cock, a detachable ring stand, and one detachable and five stationary test tube racks.

In the rear of the sink is a grooved shelf, so that with the overflow provided, the sink serves as a pneumatic trough for the collection of gases.



The hood for carrying off fumes is detachable and adjustable. By means of a taper ring of rubber slipped over the tube of the hood, the latter can be set at any convenient height and direction, the rubber ring serving this purpose as well as making an air-tight connection between the hood and the rest of the desk. The fact that each pupil has a hood on his own desk does away with the confusion always caused by pupils going to the general hood while generating fumes. Usually the latter are allowed to escape into the room, as but few can work at the general hood at a time.

For the support of apparatus at three commanding places on the top of the desk are placed sockets for receiving the upright

rod of the ring stand. Detachable test tube racks for general use are provided and may be readily attached to this rod.

Revolving stools with skeleton backs are placed before the desks, making it possible for each pupil to remain seated while at work.

The desk tops are made of rough-glass while the sinks are of enameled cast iron.

This laboratory has been in use but little over a year and has paid for itself many times over with its great advantages over the old system. The pupils work seated and isolated from each other, and all face the teacher's demonstration desk, so that teacher and pupils can see each other's work simultaneously, for there is nothing above the desks to hinder the view.

The room as it is arranged combines laboratory, recitation room, and lecture room at one time, and can be changed from one to the other, instantly, without the students moving from their seats.

The laboratory was designed and planned by Mr. L. B. Altaffer, instructor in chemistry at West High School.

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#### SOME EXPERIENCES WITH NEW EXPERIMENTS.

BY R. SPRAGUE,

*Lompoc, California.*

In what follows are given accounts of modifications of some experiments which have been described in SCHOOL SCIENCE. The modifications are not necessarily improvements in every case, but have arisen from the nature of the material I had at my disposal. The experiments themselves are so satisfactory that too much emphasis can not be paid them.

In Vol. III, page 408, appeared a description, by Mr. A. R. Hagar, of an apparatus for illustrating liquid pressure. As the principle involved had been causing difficulty to some of the

pupils in my physics class, I set up a similar piece of apparatus and was agreeably surprised at the facility with which it could be put together. Some slight modifications, however, were introduced. While I used the neck of a broken retort as a small reservoir, I did not attempt to cut off the neck of a bottle in order to make the large one, but substituted a two-liter flask, the bottom of which had been accidentally broken out. I was fortunate in having some straight tubes in the laboratory, which were provided with stop-cocks of the type found in burettes. These I introduced between the reservoirs and the respective arms of the Y-tube. It will be readily seen that these are much more handy than the rubber tubes with pinch-cocks used by Mr. Hagar; the only question is whether one is so fortunate as to have them. In case one has no damaged two-liter flask, an open-top receiver from an air pump is well adapted for use as the large reservoir.

Another most welcome suggestion I have obtained from SCHOOL SCIENCE was that made by Mr. George George in the number for April, 1903, "An Apparatus for Establishing Archimedes' Principle." Previously I had obtained the weight of the water displaced by a solid by means of an overflow can, and had found the method unsatisfactory. Mr. George's apparatus (student's lamp chimney, with rubber cork and side tube for showing the water level) works perfectly and seems to stimulate the interest of the students.

The apparatus for demonstrating vapor tension at ordinary temperatures, described by Mr. C. E. Linebarger in the April, 1902, number, has been tried and found very satisfactory. I found it necessary to substitute for the bulb tube (in which Mr. Linebarger confined the water) a test tube sealed to the end of a stirring rod. This I accomplished by partially closing a small test tube in a blowpipe flame, and then placing a lump of wax over the opening. The wax I melted by means of the flame, and then pressed the stirring rod vertically down on it. The wax quickly cooled and I had a satisfactory substitute for the bulb-tube. I replaced the L-tube and its attachments by one of my straight glass tubes fitted with stop-cocks previously referred to. To insure the dryness of the confined air, I placed a few small

pieces of calcium chloride on the bottom of the jar before corking. Of course, it may be objected that these would interfere with the subsequent evaporation of the water when the tube is broken. However, I did not experience any difficulty from this cause, as the evaporation proceeded too rapidly, the quantity of water liberated being too great to be taken up by the calcium chloride.

Several methods have been described in SCHOOL SCIENCE for getting the weight of a liter of air (see Vol. I, No. 1, and Vol. II, No. 8), but I consider that described by Mr. A. W. Gray in Vol. I, No. 9, as eminently superior to any other. His method (to weigh an electric light bulb, to make an aperture by which the air may enter, and then to reweigh, thus getting the weight of the air required to fill it, and then getting the volume by filling it with water) is so simple and accurate as, in my mind, to remove the need for any other. The only modification I introduced was to have the student make the aperture by means of a blow-pipe flame instead of by filing. The bulb was held by a stand and clamp and the tip of the flame turned on the side at about the place of maximum diameter. As the glass softened, the pupil noticed it bulging inward and finally bursting with a sharp crack, thus demonstrating by actual experiment that a vacuum existed within. While I do not say that all pupils were equally successful, it was possible by a little skill to have the aperture thus made very small and neat. This method does not obviate all filing, however, as it is necessary later to file another aperture in order that the bulb may be completely filled with water.

Our experiments were made with ordinary 16 candle power bulbs. As these have an internal volume of about 150 c. c., the air to fill them weighs 18 centigrams. Thus it is possible to get good results with balances weighing to one centigram.

## A LECTURE EXPERIMENT ILLUSTRATIVE OF VALENCE.

BY LAUNCELOT W. ANDREWS,

*Professor of Chemistry, State University of Iowa.*

The experiment about to be described is not new in principle, but the simple form of apparatus required and certain features of the manipulations recommended and of the material employed seem to justify publication. The foundation idea is to measure the hydrogen evolved from equal atomic proportions of an univalent, a bivalent and a trivalent metal, respectively, on solution in acid. Sodium, magnesium and aluminium are selected as the metals. The apparatus is represented in the accompanying figure. *A* and *B* are two glass tubes about 35 cm. in length and about 1.5 cm. in diameter. They are closed at the bottom by perforated rubber stoppers and are connected together by a short piece of narrow bent glass tubing, as shown.

The measuring tube *A* is drawn down at the top to 6 mm. diameter, while the top of *B* is open. A tube *C* of 6 mm. diameter is connected to the top of *A* by a short length of rather thin rubber tubing. When the tube *C* is bent over to one side it may be held in the position shown in the figure by a loop of wire, the connection being nicked together at *M*. The glass tube with rubber connection at *N*, which is closed by a common brass wire pinch-cock, is used for emptying the liquid out of the system and for equalizing the height of liquid in the tubes *A* and *B*.

The apparatus is made and used in triplicate. The manipulations are as follows: Place in the tube *C* a bit of aluminum wire weighing 27 mg. (respectively, 24 mg. of Mg or 23 of Ma), attach it to *A* and hook it over, the tubes *A* and *B* having previously been filled with hydrochloric acid of about 1.14 specific gravity. Slip a rubber ring over *A* to mark the meniscus of the acid solution, of course after equating the level.



When everything is ready, remove the wire hook, allowing *C* to spring into the upright position, when the weighed aluminium will fall into the acid and dissolve, the pinch-cock at *N* being opened at this time to allow the excess of acid to escape. Since bubbles of gas might be carried over with the acid if the aluminium were permitted to fall to the bottom of the tube, a slice of cork is first inserted at *X*, which, acting as a shelf, holds the metal. This cork has four or five small diagonal notches cut around its periphery with a sharp knife, thus permitting the acid to pass, but not the wire. When the metal has dissolved the hydrogen in *A* will be found to measure nearly 35 cc.

In the second identical apparatus, in which exactly 24 mg. of bright, freshly scraped magnesium band is placed, it is desirable to use a weaker hydrochloric acid, that of 1.05 specific gravity being suitable.

In the third set, sodium is employed and the technique of the weighing and introduction of this metal demands a word of explanation. It is especially simple if a sodium press is at hand capable of producing sodium wire of about 1. mm. diameter. First, ascertain what length of wire weighs 23 mgs. by running from the press about 10 cm. of sodium wire into a weighed glass tube of 3 or 4 mm. diameter and weighing again. Suppose, to take an actual case, that it is found that just 25 mm. of this wire weighs 23 mg. Prepare a glass tube of 2 mm. internal diameter and about 40 mm. long and mark it exactly 25 mm. from one end. Squeeze sodium from the press and cut it off close to the nozzle; now hold the tube against the orifice, squeeze out sodium till the wire reaches the mark on the tube, cut it off with a penknife and at once introduce the glass tube with the sodium in it into the tube *C*.

If no sodium press is available the following method can be used: Select a piece of glass tubing of a little less than one millimeter internal diameter and about eight inches long. Melt a lump of sodium in a dry test tube and dip the narrow glass tube into it, and with the mouth draw up the melted metal several inches into it, where it is permitted to solidify. With a

sharp file cut off a definite length, say 50 mm., of the tube and divide the contained sodium with a knife. Weigh the piece so removed, throw it into water and then weigh the glass after washing and drying. This gives you the weight of sodium in 50 mm. of the tube. Now cut off in the same manner the length calculated to contain 23 mg. of sodium and put it in the tube A. Either of these methods of getting a determinate weight of sodium is much easier and also more accurate than it sounds. There is no trouble in obtaining an amount within 0.5 mg. of that desired. The glass tube falls with the sodium wire into the water with which the tube A is charged, the glass preventing the sodium from sticking on the way down. The three sets of apparatus must be prepared before the lecture and set up side by side in a suitable holder. The actual experiment does not require more than six minutes, and the volumes of gas evolved are in the ratio of 1:2:3 as accurately as can be desired or expected in such an experiment. It would be well if the acid could be colored by some dye, so as to be more easily visible in a large lecture room; in a small one no such device is needed, but all dyes tried are bleached, either by the aluminum or by the sodium.

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#### OBSERVATIONAL WORK CONNECTED WITH ALMANAC DATA (II).

BY G. W. MYERS,

*College of Education, The University of Chicago.*

Like all other laws of nature the law of change of length of the day, discussed in my November paper (page 281), derives its chief value from its relations to other natural laws. It is important that the pupil should get clearly in mind not merely that the length of the time the sun is above the horizon varies from month to month for the same latitude and from latitude to latitude for the same month; but he must also be led to realize, in this connection, the effect of the varying slant of the sun's rays. A very satisfactory way of approaching this question with a high school class is by the aid of an instrument like the one shown in the

April number of the MATHEMATICAL SUPPLEMENT of SCHOOL SCIENCE (page 32) called the *helios* by Dr. H. B. Loomis, or by means of the still simpler form devised by Mr. W. S. Jackman, of the School of Education, University of Chicago, and shown here. Mr. Jackman calls this form of the device the *skiameter*. (Fig. 1.)

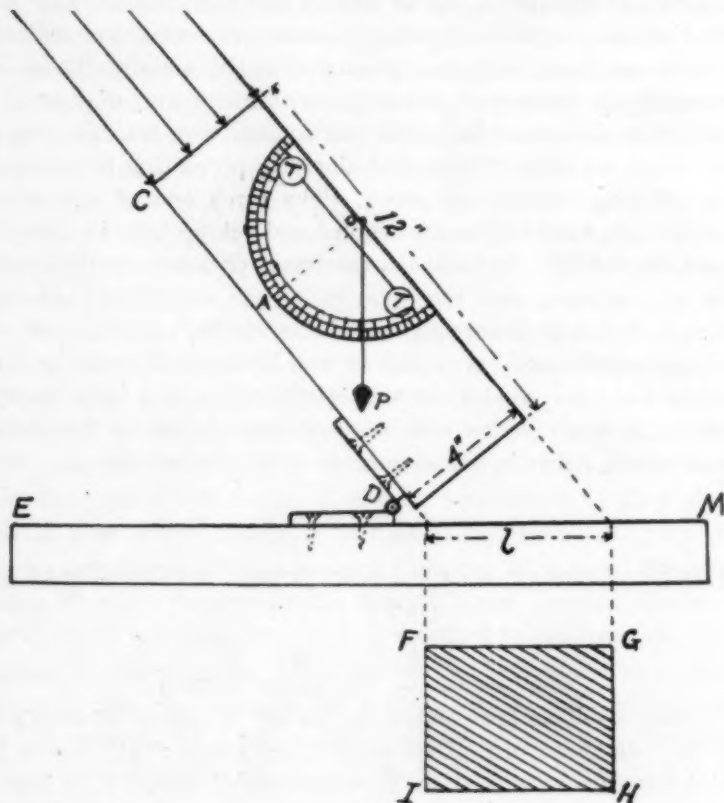


FIG. 1.

A right-prism,  $CD$ , of wood  $4 \times 4 \times 12$ ", is hinged to a baseboard,  $EM$ , at  $D$ . A protractor and small plumb-bob are pinned to the side of the prism as shown.

The baseboard should be leveled by placing a round marble upon it and the prism pointed toward the sun so as to make the shadowed rectangle at  $l$  as small as possible. The illuminated

rectangle of the skiameter has been replaced here by a shadowed rectangle (shown at *FGHI*) 4" wide and of varying length, depending upon the slant of the sun's rays. There will be no difficulty in getting the pupil to understand that the shadowed rectangle is the surface that would, if the prism of the skiameter were removed, be illuminated and heated by the square prism of rays of the same cross-section as that of the skiameter prism.

Since every other equal area of the horizontal surface of the earth is heated and lighted in the same degree as the shadowed rectangle would be, if the sun's rays were unobstructed, this shadowed rectangle may be used as a standard for estimating the heating (or lighting) effects of the sun's rays. Since the definite quantity of light and heat intercepted by the prism, which is set to point directly toward the sun, is, under normal conditions, spread over the shadowed rectangle, it is clear that a given unit of the area—say one square inch—is heated and lighted with an intensity which varies inversely as the area of the rectangle varies. The intensity of the heat, or light, which means the amount of heat (say in *calories*) or of light (say in *candle-power*) per unit of heated or illuminated area, and may at first be spoken and thought of by the beginner as the *depth* or *thickness* of heat or light.

The width of the rectangle always remaining 4", its area will vary directly with its length. Consequently the *lengths* of the rectangle, which are measured, may be taken as standards for comparing the intensity of the heating and lighting of the surface as depending on the varying slant of the sun's rays from time to time. Here is a good opportunity to teach "Rectangles of the same width are as their lengths." The slant of the rays may be read directly from the protractor as the angle, *AOC*. Why is the angle *CDE* equal to the angle *AOP*? Here is the place to teach angle as the amount of turning of a rotating line—also the angle and arcual degree.

The values of the slant and of the lengths of the rectangles read from hour to hour for October 27, 1903, are given in columns two and three, respectively, of the table.

The observed values of the slant, shadow-lengths, and inten-

sities corresponding to each hour from 7:00 a. m. to 4:00 p. m. respectively, are given in columns 2, 3 and 4 of the table.

| Hour. | Slant.<br>Deg. | Shadow-<br>Length.<br>Min.-Sec. | 48.8<br>I = ———<br>Length. |
|-------|----------------|---------------------------------|----------------------------|
| 7:00  | 4.7            | 48.8                            | 1.00                       |
| 8:00  | 14.8           | 15.9                            | 3.12                       |
| 9:00  | 24.0           | 9.8                             | 5.14                       |
| 10:00 | 30.8           | 7.8                             | 6.47                       |
| 11:00 | 34.3           | 7.1                             | 7.02                       |
| 12:00 | 34.9           | 7.0                             | 7.12                       |
| 1:00  | 32.4           | 7.5                             | 6.67                       |
| 2:00  | 26.6           | 8.9                             | 5.57                       |
| 3:00  | 17.8           | 13.1                            | 3.81                       |
| 4:00  | 8.0            | 28.7                            | 1.75                       |

The values of the slant from hour to hour are laid off to scale on the system of parallel and equally-spaced verticals shown in the drawing of Figure 2.

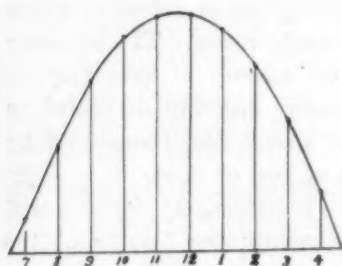


FIG. 2

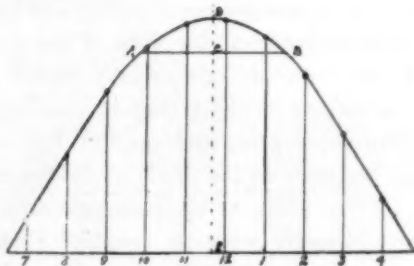


FIG. 3.

Drawing the line,  $AB$ , parallel to the base line of the drawing, bisecting it, and erecting a perpendicular,  $DE$ , at the middle point,  $C$ , the point,  $D$ , where the perpendicular cuts the curve is the noon point. Interpreting the position of the point,  $R$ , in time we find that apparent noon occurred at about 11:40 a. m. on this date. The American Ephemeris gives 11:44. Although this result can hardly be considered accurate enough for a determination of the error of the timepiece, the method at least has the virtue of indicating quite clearly the principles on which such a determination depends. That there is a real difference between sun time and mean time (correct clock time of the place) and that

there is a simple way of getting at this difference experimentally are made pretty clear to the student.

The hourly values of  $l$  (the length) are laid off to scale on a similar system of parallel verticals in Figure 3. The curves visualize the fact that at apparent noon both the slant and the intensity of light and heat are greatest. This means, of course, that the direct values of the slant, light- and heat-intensity are greatest at apparent noon. But the intensity of heat is cumulative, while the slant and light-intensity are not.

The study may here profitably shift to the explanation of the well-known fact that the hottest part of the day actually occurs

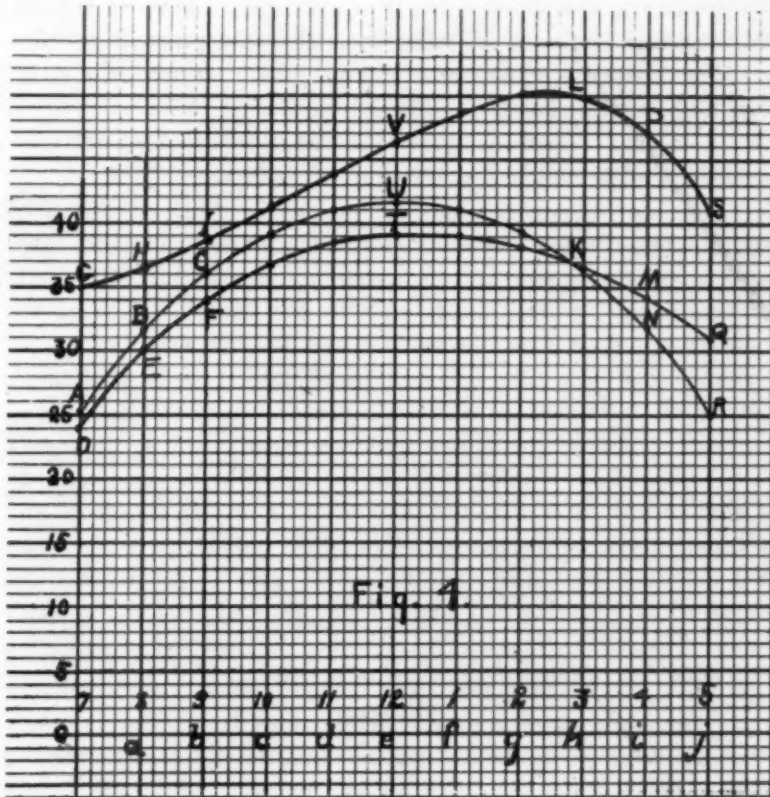


FIG. 4.

not at noon, but at about 2 p. m. The use of the graph may here again be called into requisition to impress upon the class how it comes about that the temperature must continue to rise so long as the income of solar heat is greater than the outgo from the earth's surface, must cease to rise when income and outgo become equal and must begin to fall so soon as the outgo exceeds the income. This is not an easy idea to teach properly and its importance justifies the expenditure of a little time upon it.

In the drawing (Fig. 4) let  $OA$  represent to scale the number of heat-units received by a square unit (say  $1m^2$ ) of the earth's surface from 6 a. m. to 7 a. m.;  $aB$  the number of units received from 7 a. m. to 8 a. m., etc., to  $jR$ . Then the curve  $ABC \dots R$  pictures the hourly receipts of heat from 7 a. m. to 5 p. m.

But heat and light are being simultaneously given off, or radiated, by this same square unit of area. Let  $OD$ ,  $aE$ ,  $bF$ ,  $\dots jQ$ , denote the hourly radiations of heat from 6 a. m. to 7 a. m., 7 a. m. to 8 a. m., etc. Then the curve  $DEFTMQ$  pictures the hourly expenditures of heat by the square unit of surface.

The earth's surface, however, warms or cools by reason of the difference between receipts and expenditures. Suppose, then, at 7 a. m. the square unit in question contains thirty-five units of heat energy, represented to scale by the line  $OG$ . During the hour from 7 to 8 a. m. the surface unit receives according to the diagram 31.7 heat units and radiates off into space 30 heat units, giving an increment equal to 1.7 heat units, making the total content of heat of the square unit now equal to  $35 + 1.7 = 36.7$  heat units. This is represented in the figure by the line  $aH$ . In a similar way by adding the increment  $CF$  to  $aH$  obtain  $bI$  and ultimately the entire curve,  $GHIVLPS$ . This gives the diurnal curve of total heat quantity. This unit of surface may be regarded as typifying any and all the units exposed to the sun's rays. The curve,  $GHIVLPS$ , may then be regarded as picturing the daily heat change for an entire locality.

#### QUESTIONS.

1. When is the hourly income equal to the hourly outgo of heat?

2. When is the difference of income and outgo greatest?
3. When is the income greater than the outgo? Less?
4. When is the total store of heat in the square unit greatest?
5. When does the curve of total heat store rise fastest? Fall fastest?
6. Tell now why the hottest time in the day is not at 12 m.
7. Tell why the curve of total heat continues to rise after the income of heat has begun to fall off.
8. Explain why the hottest time in the year is usually after June 22. Use the curves of Figure 4.

It may be worth while to have the pupil construct the curves from assumed monthly incomes and outgoes of heat furnished by the teacher to clear up this important law. One law well worked out and clearly grasped is worth more to the student than vague general ideas of a dozen. This is remarked for the encouragement of those teachers who are so prone to imagine they can not take time to teach anything well.

My next paper will deal with ways of using common almanac data relating to the moon.

## A HOME-MADE HIGH FREQUENCY COIL.

BY N. HENRY BLACK,

*Instructor in Physics, Roxbury Latin School, Boston.*

The principles involved in the construction of this coil are not in any way novel, for they have been used by the inventors, Tesla, Thomson and Kinraide, in their high frequency coils. The real advantage of this form of construction is that it is inexpensive, easy to build in the workshop of any good physical laboratory, and in case of a breakdown the fault can be quickly detected and repaired, because of its openness of construction.

The general arrangement of the parts of the coil is shown in Fig. 1, where *F* represents the fuses (15 amp.) in the 110-volt alternating current mains, *S* the two-pole jackknife switch, *R* the adjustable rheostat, *T* the step-up transformer, *P*<sub>1</sub> the primary and *S*<sub>1</sub> the secondary, *C* the condenser, *G* the spark-gap, *H F C* the high frequency coil, of which *P*<sub>2</sub> is the primary and

$S_2$  the secondary and  $t$  its terminals. The adjustable rheostat consists of about three pounds of No. 12 German silver wire (18 per cent) wound up in spirals and mounted on a frame.

The step-up transformer consists of a laminated core of mild steel and a primary coil of 300 turns of No. 10 double cot-

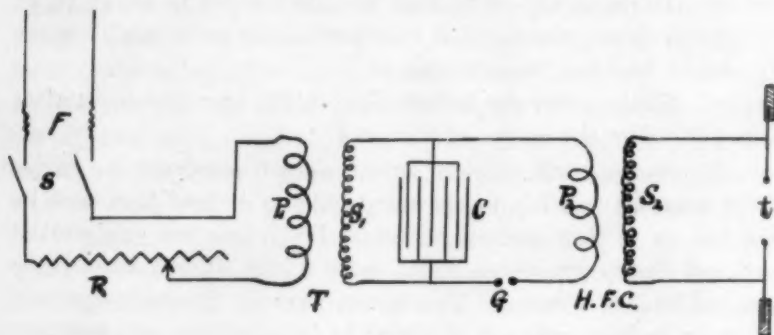


FIG. 1.

ton-covered copper wire, and a secondary of approximately 30,000 turns of No. 30 double cotton-covered copper wire. Fig. 2 shows a vertical section of the transformer and end view of the core. The core ( $\theta$ ) is built up of strips of iron, half of which are 7.5"x1-.5"x0.012" and the other half are 4.5"x1.5"x0.012". These are placed in the form of a rectangle, as shown in the figure, each layer being so placed at the corners as to break the joints of the preceding layer. The whole is then bolted together at the corners. The sides are wound with tape and then the top bolts are removed and the top piece is taken off. The primary coil is wound in two parts. This winding is done on a wooden form (Fig. 4), which is put in a lathe. The form is made in two parts to enable it to be slipped apart to get off the coil. The coils are shellaced and then baked for a couple of days. The wire is so large that the coils hold their shape without much trouble. After the coils have been slipped on the core they are wrapped with two layers of oiled linen ( $L$ ), such as is used by dynamo repairers.

The secondary is made up of eight separate coils,  $S_1$ ,  $S_2$ ,  $S_3$ , etc., in Fig. 2. These coils are wound on a wooden form (Fig. 5), which has shoulders projecting about an inch all around

above the body of the form. It would be possible to get much more wire on the secondary if time were taken to wind the wire on smoothly layer by layer, but I did not take this trouble and wound up the coils at a pretty high speed on the lathe. During the winding shellac is applied frequently enough to saturate the whole coil, which is then baked till dry. Pulp-board (B) is used

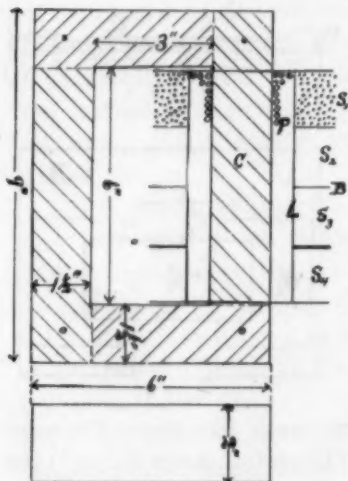


FIG. 2.

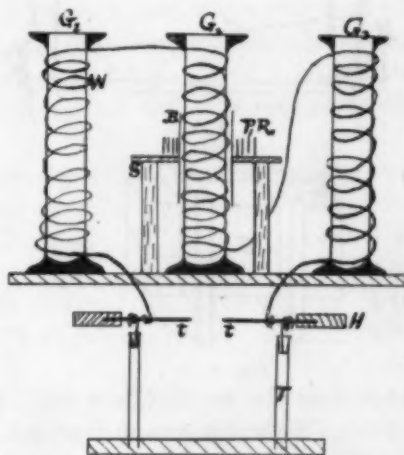


FIG. 3.

to separate the adjoining coils. The coils are joined up as follows: The outside terminal of  $S_1$  is connected to the binding post on top of transformer, the inside end of  $S_1$  is connected to the inside end of  $S_2$ , the outside end of  $S_2$  is connected with the outside end of  $S_3$ , and so on, great care being taken in each case to wind and place the coils such that the current goes around the core continuously in the same direction. The coils (both primary and secondary) on the two sides of the transformer must be connected so as to send the flux around the core in the same direction; otherwise the two sides of the transformer will oppose each other.

The condenser, which is shown in the foreground of the cut of the assembled apparatus, is one of the critical points in the outfit. The simplest style of condenser for high potential experiments consists in a stack of sheets of glass interleaved with layers

of tinfoil with a connection brought out at one end from every alternate layer of tinfoil, and a similar contact made with the other layers at the opposite end. I have given up this style of condenser because the electricity persisted in piercing and thus breaking the glass. The form shown in the cut is cumbersome,

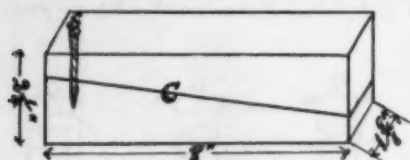


FIG. 4.

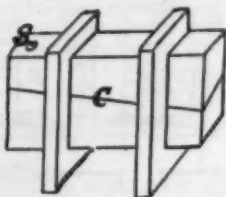


FIG. 5.



FIG. 6.

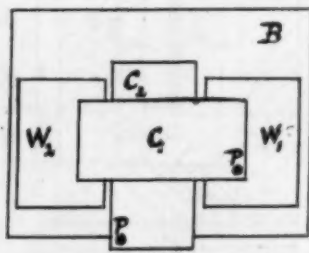


FIG. 7.

but does the work. It is built very much like those Professor John Trowbridge uses at Harvard. The tinfoil sheets (6"x8") are shellaced on to each side of the sheets of glass (10"x12"), then these sheets of glass are mounted in a wooden frame with 1.5" spaces between. The connections are made with the tinfoil by means of copper wires soldered to strips (2"x1") of thin sheet copper, which are in turn cemented on to the tinfoil with shellac. By means of single pole jackknife switches the number of plates of the condenser in use may be quickly varied.

The spark gap(\*) is designed to give a large cooling surface. It is shown in cross-section in Fig. 6, and a plan is given in Fig. 7. *B* is the baseboard, *C*<sub>1</sub> and *C*<sub>2</sub> are copper plates (6"x-3"x0.15"); the lower one, *C*<sub>2</sub>, is screwed to the board, while the upper one, *C*<sub>1</sub>, is supported at each end on wedges, *W*<sub>1</sub>, fixed, and *W*<sub>2</sub>, movable, so that the distance between the plates may be adjusted. *P* represents a binding post attached to each plate.

The high frequency coil is shown in Fig. 3, where *G*<sub>1</sub>, *G*<sub>2</sub> and *G*<sub>3</sub> are glass hydrometer jars (18"x3"), which are covered

(\*) Suggested by Mr. Leon Chaffee, of Somerville, Mass.

with a single layer of double cotton-covered copper wire, No. 30, wound on evenly and closely. These coils are joined in series to form the secondary. The ends are brought out to a couple of brass-pointed rods mounted on glass tubes (*T*). The primary coil (*P R*) is a spiral of copper ribbon (1.5" wide), insulated with braid, such as is used to bind rugs. *B* is a collar of pulpboard to separate the primary and secondary coils. *S* is the supporting frame. It will be seen that while this form of high frequency coil is bulky and offers considerable chance for the leakage of electricity, yet does not have to be immersed in oil, which usually bothers by leaking out, and it is very accessible for adjustment.

The following list of materials, with their approximate cost, may be helpful to one planning to build such a coil:

|  |         |
|--|---------|
| 16 lbs. transformer iron at 15c.....   | \$ 2.40 |
| 10 lbs. No. 30 D. C. copper wire at \$1.....   | 10.00   |
| 7 lbs. No. 10 D. C. copper wire at 20c.....  | 1.40    |
| 3 doz. panes of glass (10"x12") at 60c.....  | 1.80    |
| 3 lbs. tinfoil at 30c.....   | .90     |
| 3 lbs. No. 12 G. S. wire (18 per cent) at 70c.....   | 2.10    |
| Miscellaneous items: Pine lumber, switches, fuses, binding posts, pulpboard, oiled linen, copper ribbon, tape, copper plates, hard rubber rods, glass jars, etc..... | 6.40    |

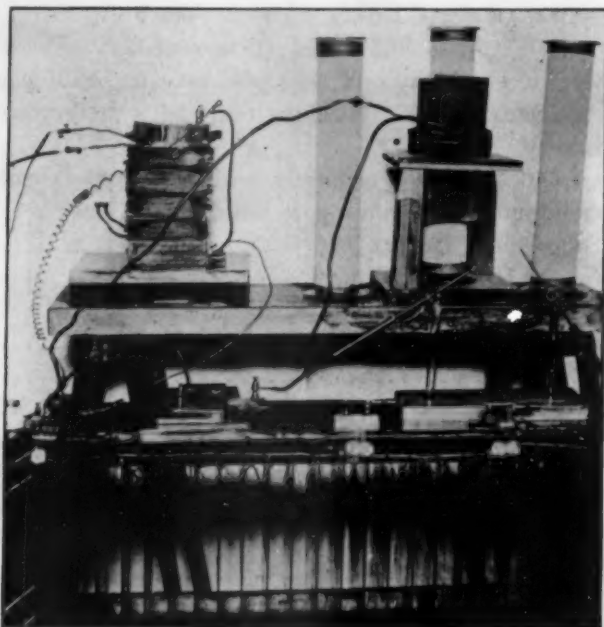
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Total .....\$25.00

The cost for materials would probably not exceed \$25. In undertaking to build such a coil I should advise a fellow school-master to take plenty of time and do everything thoroughly and be prepared to spend your leisure moments on the job for perhaps a year.

Finally, a word as to the adjustment and working of such a coil: It must be said that every individual coil must be attuned to give the best result. The variable factors, which are easily changed, are these: (1) Strength of the 110-volt alternating current by means of the rheostat (*R*); (2) length of the spark gap (*G*) by moving the wedge (*W<sub>2</sub>*); (3) number of turns on the primary of the high frequency coil by sticking the movable wire

in at various points on the spiral (I found less than six turns gave the best results); (4) capacity of the condenser by varying the number of plates, and (5) inductance in the high frequency coil by varying the number of turns on its secondary. By varying these five factors I have been able to increase the spark of this coil from 1.5" to 7.5".



In case the alternating current is not available, the high frequency coil with the condenser and spark gap can be used with a regular induction coil in place of the step-up transformer. For X-ray work the single focus tube can be used with this high frequency coil, but much better results will be got from a tube especially built for this type of coil, such as Swett & Lewis (\*) Company's type H. A coil of this type would cost in the market from \$125 upward, and so, if it is a question of building one for \$25 or not having one at all, it may be worth while to consider building such a coil.

(\*) No. 18 Boylston street, Boston, Mass.

# A SIMPLE EXTENSIMETER.

BY H. N. CHUTE.

Select a metallic tube of about 5 mm. bore and 80 cm. long. At 10 cm. from one end drill a hole perpendicularly through the tube and solder in it a stout wire, projecting 2.5 cm. from each side. At the same distance from the other end solder a similar wire in a plane with the first one, but not extending through the tube. Fig. 1 shows the arrangement of these projecting wires.

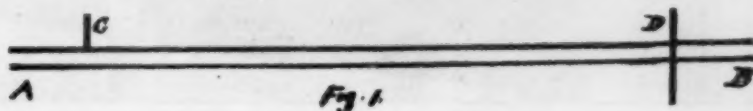


Fig. 2.

Support the tube on the wooden stand (Fig. 2). In the top of the block *F* there is inserted a small metal tube, into which the wire *D* fits snugly. Block *E* is higher on one side by the thickness of the rod, and is provided with a thin block of wood and a thumbscrew, so that a wire micrometer may be fastened rigidly on top with the face of the screw of the micrometer resting against the wire, *C*.



FIG. 3.

Fig. 3 shows the micrometer in place and Fig. 4 shows the whole apparatus. A rubber tube connects the end, *A*, of the metal tube to a generator of steam, and a second rubber tube is connected to the end, *B*, to carry away the issuing steam.

The wooden base may be protected from radiant heat by a strip of asbestos. The micrometer used should have a slip head to indicate contact.

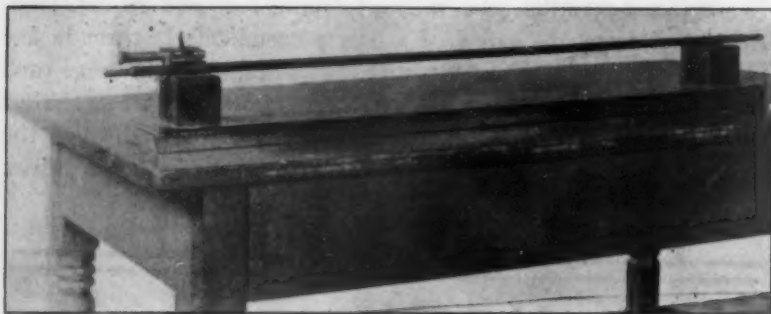


FIG. 4.

The tube may be cooled to nearly zero by passing ice water through it, the exact temperature being found by taking that of the water issuing at *B*. While the tube is full of ice water, find, by applying a meter stick, the distance between the inner faces of *B* and *C*. This will be the initial length of the tube. The micrometer reading should also be taken at this time, the head being turned till the face of the screw touches the wire, *C*. Now turn the screw back two or three millimeters and heat the tube for several minutes by passing steam through it. The temperature of the heated tube will be that of the escaping steam. Turn the screw till contact with the wire, *C*, is secured, and take the reading. The difference between the two micrometer readings will be the expansion and the mean coefficient of expansion may be calculated in the usual way.

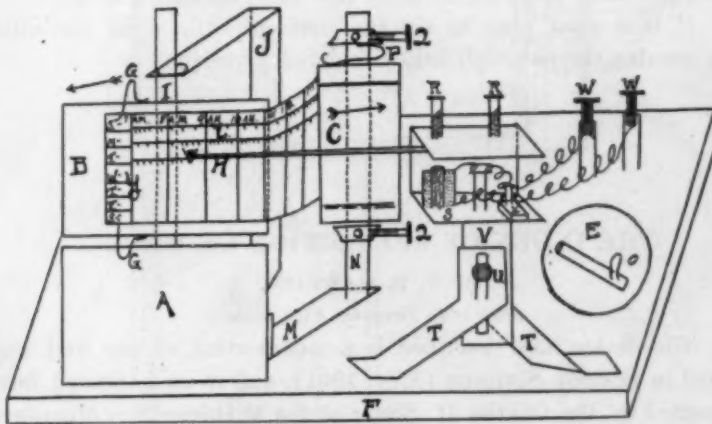
## A SIMPLE ANEMOGRAPH.

BY E. MARSH WILLIAMS,

*Instructor in Physiography, Lyons Township High School, La Grange, Ill.*

In order to obtain the best results from a study of the interrelation of the weather elements, it is necessary to have more frequent meteorological data than students are able to make by occasional observation. Recording instruments should be used and so located that students may make their own readings with little effort and confusion.

The accompanying drawing illustrates a serviceable and easily constructed recording attachment for an ordinary anemometer. The entire cost is very small, which is an important item, since the expense of recording instruments prohibits their introduction into the average school.



A is an ordinary alarm clock. B is the case of another clock, with the ends soldered fast to serve as a drum. I is a piece of blowpipe soldered over the bushing of the hour wheel; this is supported by a brace, J, soldered to the clock case. G G are spring clips for holding the record paper, Y, which is wound on a wooden drum, C. P is a friction spring to prevent the paper from uncoiling. C may be omitted and the instrument adjusted

every twelve hours, but this is troublesome. *Y* is a strip of ledger paper thirty inches long, marked to show the days of the week and hours of the day. *S* is a small electro-magnet taken from a physiological time-marker, with a spring stylus, having an ink trough at *H* and soldered to the spring armature. *S* is supported on an adjustable device, *V T*. *E* is a switch, convenient but not necessary.

To attach to the anemometer, remove the cyclometer crystal and drill a hole, by means of a file and turpentine, through its center and bolt a brass contact spring on the inside, using a small binding post and leather washers. Bend this spring to make a contact with the cyclometer pointer, which indicates one mile with each revolution. Complete the circuit from the binder post just put in and the frame of the anemometer to the recording instrument. Put in some accessible place and the wind velocity will be recorded in miles per hour, as shown at *L*.

It is a good plan to tip the contacts with sheet platinum. Use regular thermograph ink or colored glycerine.

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### THE INDEX OF REFRACTION OF WATER.

BY V. D. HAWKINS,

*Joliet (Ill.) Township High School.*

The device here described is a modification of one first suggested in SCHOOL SCIENCE (May, 1901), and in an improved form presented by Mr. Charles H. Slater at the Michigan Schoolmasters' Club in 1902. It can be used in the laboratory with ordinary light and in the hands of the average student gives less than one per cent error.

A rectangular glass jar (we use a plunge battery jar) is filled with water. A hardwood board about 10 cm. by 22 cm. is grooved to fit the top of the jar. Two meter sticks, each about 25 cm. long, are mortised into the board at right angles (Fig. 1). A coarse wire or rod *m g*, passes through one opening in the

board and is held by two binding posts in a position perpendicular to the under surface of the board. Near the center and so that the distance  $Ej$  and  $jo$  shall each be about 10 cm. is a hole 2.5 cm. in diameter. Across this and at right angles to the line  $eo$

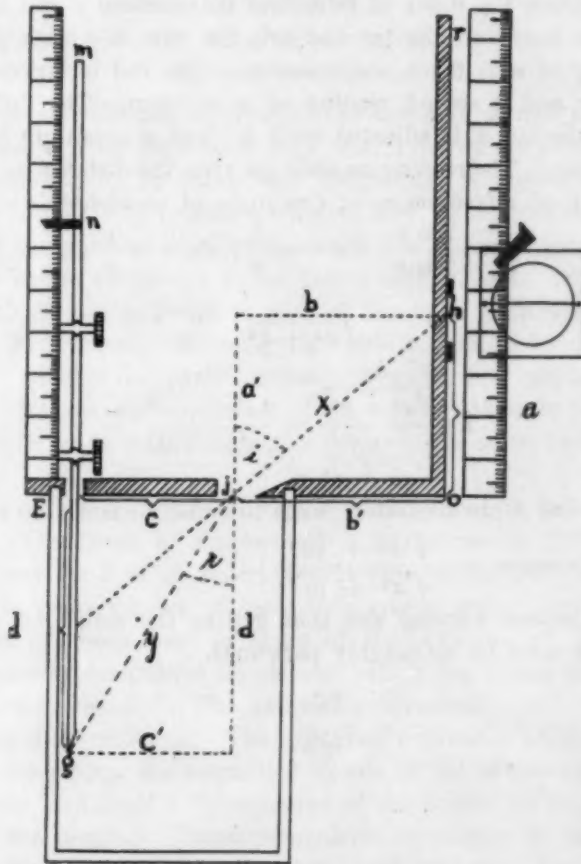


FIG. 1

is stretched a cross-hair, or better a fine platinum wire. The meter stick  $or$  supports a cardboard having a circular opening across which is stretched a cross-hair.

To get an idea of the effect of refraction the student first sights  $h$ ,  $j$ , and  $g$ , in a straight line with the jar empty. Then he fills the jar with water until a thin film covers the cross-hair. One glance along the line of the cross-hairs makes the effect of refraction appear very real to him.

To obtain the index of refraction he measures  $c$  and  $b$ , then places the board on the jar and sets the wire  $mg$  with  $g$  at  $e$ . A reading of  $n$  is taken and recorded. The rod is lowered into the water and a second reading of  $n$  is taken. The difference is  $d$ . Cross-hair  $h$  is adjusted until  $h$ ,  $j$  and  $g$  appear to be in a straight line. The reading on scale  $ro$  gives the distance  $a$ . Then

Index of refraction  $= u$ ;  $i$  = angle of incidence;  $r$  = angle of refraction.  $u = \frac{\sin i}{\sin r}$ ;  $\sin i = \frac{b}{x}$ ;  $\sin r = \frac{c}{y}$ ;  $x = \sqrt{a^2 + b^2}$

and  $y = \sqrt{c^2 + d^2}$ ;  $\sin i = \frac{b}{\sqrt{a^2 + b^2}}$ ;  $\sin r = \frac{c}{\sqrt{c^2 + d^2}}$ ;

$$u = \frac{\frac{b}{\sqrt{a^2 + b^2}}}{\frac{c}{\sqrt{c^2 + d^2}}} = \frac{b \sqrt{c^2 + d^2}}{c \sqrt{a^2 + b^2}}$$

If  $c$  and  $b$  are accurately made to be each exactly 10 cm. the formula becomes  $u = \frac{\sqrt{d^2 + 10^2}}{\sqrt{a^2 + 10^2}}$

To prevent warping and thus getting the scales out of line the board must be thoroughly paraffined.

### Metrology.\*

#### THE METRIC SYSTEM PSYCHOLOGICALLY CONSIDERED.

BY WILLIAM F. WHITE.

(Continued from page 105.)

It is not difficult to *predict* that the *first* named plan will be followed. After the system is in general use by the government, the people will follow slowly and irregularly. Congress will not take the initiative by passing a coercive law. It is proverbially the attitude of representative legislative bodies to wait for popular pressure before acting—to follow rather than to lead. Sometimes the result is costly, but it is part of the price of representative popular government. Metrology is not a matter in which either financial interest or party enthusiasm makes the popular will urgent. No one *expects* the use of the metric system in our commerce to be made compulsory; this discussion is as to what *ought* to be.

Many have a dislike to any legislation that is called compulsive. The house of representatives committee in 1897 made haste to say (p. 2 of its report): "It [the metric bill] does not propose to make the use of the metric system compulsory on the people as has been done in many of the countries of Europe." But in case of compulsive legislation, who is the tyrant that tells us what we must do? The national government. And what is the national government? The organized expression of the popular will, its officers the accredited agents of the sovereign American people, and itself a "government of the people, by the people, and for the people." Hence compulsive legislation is our form of compelling ourselves. It has been said that "*must* is a hard word, but loses its sharpness when applied by oneself to oneself."

But what is the need of coercive enactment? This touches the kernel of the matter. There are movements in which society

Communications to the Department of Metrology should be sent to Rufus P Williams, North Cambridge, Mass.

must act together—all must begin at the same time. Each fears to start lest others will not join in. Who has not seen a large company all ready to sing in concert? The pianist plays the prelude, the first note of the first stanza is passed, perhaps the entire stanza is played, without a voice being raised. Why? Everybody is ready to sing, but hesitates to start till others do. Again that congregation is ready and a precentor is on the platform. He gives the signal, and the first note is sounded loud and clear by all. Congress is that precentor to give the signal. The commercial and industrial interests are ready to put the metric system into use if each person, each corporation, can only be assured that at the same time all others will start. The law must be imperative enough to give that assurance.

Manifestly, legislation to make the use of the metric system obligatory might take many forms, differing widely in the extent of the compulsion and in the nature of it.<sup>14</sup> Just how the law should make such use compulsory is not a question likely to be settled by academic discussion. But clearly there should not be, and doubtless there never will be, any law to hinder any person in the manufacture or use of any implement (not a weight or measure used in buying or selling) made in dimensions of any system that has ever existed. On the other hand, it is clear that those who, by governmental concession or protection, enjoy the privilege of transacting business publicly are amenable to governmental regulation for the public good. Society has a right to name the weights and measures in terms of which such business shall be done.

But—it may be objected—should people be compelled to do anything that they do not want to do? If the few do not voluntarily conform to the wish of the many in those matters in which no personal right is involved and in which uniformity is essential to the stability or, as in this case, to the well-being of society, they may justly be put under compulsion to do so. All governments since the dawning of history have acted on this principle. A republican form of government in no way lessens the obligation.

But suppose a majority of the people are opposed to the

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<sup>14</sup>E. g. One suggestion is, that contracts, bills of sale, etc. be required to be in metric terms to be valid.

change. Then the change would not be made, ought not to be made, and ought not to be enacted. No one who has imbibed the spirit of free institutions desires to compel an unwilling people. But all the evidence goes to show that, so far as the American people are informed on the subject, they very generally favor the change.<sup>15</sup>

Many persons will have no opportunity of knowing whether they favor the metric system or not until it is in actual use in business. Then, like the people of all the countries that have adopted it, they will be its warm supporters. The evidence adduced shows that the intelligent public wants the system adopted. It is time for congressional action.

The determination of weights and measures has always and everywhere been deemed to be a function of government. It inheres in sovereignty. It is like coinage in this respect. But the introduction of a change in weights and measures is very different from a change in coinage, for the reason that the government makes all the coins and can gradually put the new ones into circulation by paying its debts in them. The case of weights and measures is a case of social coöperation.

The essential thing is that it be known that after a certain date a law is to be enforced. Then there will be little need to enforce it. A few years ago several commercial exchanges set a date on and after which all their transactions were to be in terms of the metric system. After an attempt, the plan was abandoned. Others were not using the system, and there was no one to compel its use. They wished to use it, but there was no force to crystalize the general desire.

After a day has been set far enough in the future, nothing is gained by further procrastination in adoption; but much is lost. Most of the reasons for the metric system apply solely or mainly to that system used by itself. There are things much

<sup>15</sup>Among the evidences of this may be cited the press, that mirror of popular feeling. A collection of clippings on the metric system (the property of the N. Y. state library at Albany) including every clipping that the collectors could find in newspapers and periodicals of all sorts, contains several hundred clippings. Fully eighty per cent of them were found to distinctly favor the introduction of the metric system in this country.

more costly to do gradually than by concerted action. The adoption of a system of weights and measures is one of them.

It is worthy of note that the resolution of the congress of chambers of commerce of the British empire, passed in June, 1900, was that the metric system "after a period of two years be everywhere rendered compulsory by Act or Ordinance."

The bills recently before congress proposed, in addition to what is already accomplished, only the exclusive use of the metric system in government business and the setting of a day on and after which people were expected to employ the metric system if they should see fit. This would be all that any one could ask, if it would bring about a general use of the system without a tedious and expensive transition period after the day appointed for adoption. In any case, it would be a long step forward; for government use would be very important in itself, would promptly influence many individuals, and would probably in time affect all. But that a feeling against compulsion—on the part of a republican government!—should cause unnecessary inconvenience and stand in the way of the most economic method of making the change, is to be deplored.

Much would be done in preparation for the change if the national government would make the announcement for the schools under its control and for the civil service, and request the several states to do the same for their institutions, that in future all examinations that should be set would presuppose acquaintance with the weights and measures of the metric system, but not with the English weights and measures. That would promptly bring the schools into line.

The period of preparation should be long enough to meet all reasonable requirements, but there should be a day beyond which, at any rate, it is known that the metric system is to be used. One who was a clerk in a store in Germany in 1873, said: "One day the officers of the Government came around with the actual new measures . . . and notified the people that, commencing on such and such a day, none but these measures could be used lawfully to sell or buy with. The day came around, and, the metric measures being in actual use, there was no longer any necessity for comparing them

or translating them into the old method. Everybody 'fell into' it at once without any difficulty."<sup>16</sup> Another, speaking of the same time, says: "It . . . was found to work so well that when the compulsory time came there was nobody to be compelled."<sup>17</sup>

Among the important functions of government are these two: to take the initiative in movements for the popular good, and to secure concert of action in social progress. It was with such conception of the scope of government that the framers of the constitution devolved upon congress the authority—and may we not say therefore, by implication, the duty?—"to fix the standard of weights and measures."

#### TEACHING OF METRIC SYSTEM.

The teacher of the metric system must himself know that system! It is not enough that he is able to recite all the tables; the metric system must have passed beyond that stage in his mind; he must have "not merely information, but insight"; the system must be his own; he must be able to use it. Many a teacher of arithmetic has taught the metric tables when he could not have estimated his own weight in kilograms, or the length of this page in centimeters, with any approach to accuracy. He was not prepared to teach the subject. The lack is hardly excusable, considering that one may familiarize himself with the metric units by actually using them for a short time.

It is also necessary that the teacher know much *about* the metric system—in what its essential characteristics lie, why the units of length, capacity, and weight are related as they are, why the system is decimal, what are its advantages and its application to various kinds of work, its variant forms of nomenclature and abbreviation, and the etymology of the terms used, and to what bureau of the national government he may write at any time for latest or more minute information on any metrological matter. He should, if possible, be acquainted with some of the best works on the metric system. And he should certainly know something of the history of the origin and spread of the system. Some teachers

<sup>16</sup>Isaac Mondschen, Cincinnati. Report from the committee on coinage, weights, & measures, on H. R. 2758. Report no. 795, 54th cong. 1st ses. p. 14-15.

<sup>17</sup>Mr. Siemens, same report, p. 18.

will achieve more with a meager preparation than some others can with the most painstaking; but thorough preparation is necessary for each teacher to do *his* or *her* best.

In the law of association of ideas is expressed the mental necessity for him who would have "enthusiasm not without knowledge" that he interest himself in matters related to the subject in hand. He will, of course, not communicate to the class much of the information *about* the subject; he must know much more than he teaches. And that additional knowledge has the most marked effect on his teaching. As when one draws a pailful of water from a faucet, the force with which it gushes forth depends upon the "head" of water, which will be *maintained* only by a large volume of water in the reservoir on the hillside—the millions of liters that he does not want determining the power with which he gets the few liters that he does want—so in teaching, the reservoir of knowledge of the connected things one does not teach determines the force of what he does teach. It gives him sustained power and consciousness of power. Such related knowledge contributes to accuracy; it puts things in their proper bearing; it enables one to come directly to the essential point and bring all resources to bear upon it; above all, it gives him contagious enthusiasm.

It is presumed that as soon as the congressional decision shall be made in favor of the change to the metric system the schools will act promptly in order to assist in the transition. But what is the place of the metric system in the curriculum previous to legal adoption? The system is used to such an extent in science and has so much of educational value that it should not be left until the high-school course. Experience shows that it may profitably be taken up in any of the grammar grades.<sup>18</sup> The place for introducing it will depend to some extent on the nature of the science work in those grades. The question has also a very close connection with that of the pupils' facility with decimals.

The metric system is essentially a *decimal* system, and it must be ascertained at the outset whether the class has a working knowledge of decimals. Few errors psychologically are more to be deplored than the very common one of presupposing on the part of

<sup>18</sup>That is, the intermediate grades—grammar school in the American sense.

pupils a thorough acquaintance with that which, in fact, is but imperfectly understood. Decimals have been poorly taught in many schools. About two years ago the writer devised a test, which was made with eighty men and women not employed as teachers or accountants. Only thirty-six could perform a very simple operation in decimal fractions. Even of this number, sixteen preferred to use "common fractions," although in the particular example chosen that method involved more work. Forty-four persons, or 55 per cent of the whole, were helpless in the presence of decimal fractions of the simplest sort. But of the eighty asked, all but four were able to work the example by "common fractions." Some significant remarks were reported from this test. Two who used "common fractions" said: "They are easier than decimals."

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The rest of Dr. White's paper is substantially the same as given in his article, "The Teaching of the Metric System," in Volume II, page 350 of this journal.

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*Land Measurement in the Philippines.*—The "Philippine bill," which passed the House of Representatives April 14 by a vote of 139 to 123, contains a provision reaffirming for land measurement the use of the metric system, which was long ago established in that country, but whose units the original act had changed to acres. Thus has a metric bill actually passed the House, and that, too, for measurement of land.

*History of the Metric System.*—The paper of Dr. S. W. Stratton before the Eastern Physics Teachers March 19, published in full by that Association, contains the most complete brief history of the metric system that has yet come to our notice.

*For Athletic Sports.*—If schools and colleges were to make use of the international system of measurements for athletic sports, progress might be made in the right direction. This was done at the Clyde School, Hereford, last June, where, for the first time in England, "athletic sports were held under metric measurements. It is a novelty that would naturally appeal to the student athlete and make the events easily comparable to those in other countries, besides being distinctly educative.

R. P. W.

## Notes.

## CHEMISTRY.

Ramsay recently reported that the proportion of krypton in the air is 1 to 20 million and of xenon 1 to 170 million. The boiling point of krypton was given as  $-151.7$  and of xenon as  $-109.1$ .

Recent work by Dewar and Moissan has shown that solid fluorine and liquid hydrogen interact with explosive violence at  $-252.5^{\circ}$ .

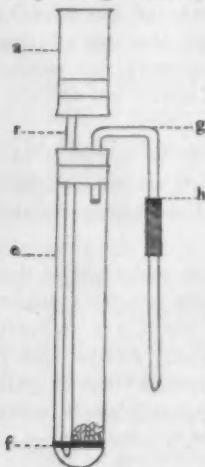
Several recent articles have emphasized the action of the International Congress of Applied Chemistry in calling attention to the necessity of having a more specific definition of an element. It was agreed at this congress that "no new substance should be described as an element until its spark spectrum had been measured and shown to be different from that of every other known form of matter." This view was criticised unfavorably by Dr. Baskerville in his recent address, which is published in full in *Science*, Jan. 15, 1904, page 88.

An illustrated biographical sketch of Sir Oliver Lodge is published in *Scientific American* for December 26, 1903, p. 482, and one of Sir William Crookes in the same journal for August 8, 1903, page 99.

It has recently been shown that the characteristic horse radish odor noticed when selenium is burned is probably due to selenium carbide, which even in the most extreme dilution has this odor. Most books ascribe the odor to selenium dioxide.

L. C. N.

The accompanying figure shows an easily set up form of hydrogen sulphide generator, somewhat after the plan of a Kipp apparatus. Two test tubes, two rubber stoppers, a pinch-cock and a little glass tubing is all that is needed. The bottom of the upper test-tube is taken out and fitted with a one-hole rubber stopper and a tube (r) is run from this to the bottom of the lower test tube (e) and drawn out at the lower end to a rather small opening. A cork at (f), allowing (c) to pass thru it and having in it a few small holes, is used to support the iron sulphide. The tube (g) is connected at (h) with the delivery tube, (h) being a rubber tube with a Hoffman screw fitted to it; or, better, a glass stop-cock. A funnel may be used in place of the upper test tube. I have found this very satisfactory for generating hydrogen sulphide and also for hydrogen or carbon dioxide.

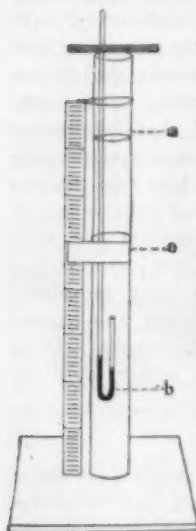


KENDALL P. BROOKS, Marquette, Mich.

## PHYSICS

I developed an interesting fact last year in regard to the use of the metric system. In a physics class of eighteen, none had used the metric system and all objected to its use in problems and experiments. In June, however, when they had used it continuously for ten months, I took a secret ballot, and found that sixteen of the eighteen preferred the decimal system, only two clinging to the old. That shows what familiarity will do.

The apparatus shown in the accompanying figure for demonstrating the pressure of liquids is not new in principle but only in detail.



The bend of the tube (b) is filled with mercury and lowered in the water contained in (a). The mercury will be pushed up in the long end of (b) by the pressure of the water, rising higher as the depth increases. Most manuals suggest that the elevation of the mercury can be measured by a scale pasted on the outside of the tube. I have found that accurate results could not be easily obtained in this way, and so have made use of a clasp (c) for the tube (a) made of spring brass and arranged to read on a meter stick. The brass is about two inches wide and bent carefully around the tube so that there may be as little side play as possible. By this means a limit of error of one per cent is possible.

I first tried to use a mirror scale behind the tube but the distortion caused by the water was too great to make it feasible. Putting the whole on a base has made it more convenient for moving from one table to another.

KENDALL P. BROOKS, Marquette, Mich.

## PHYSIOLOGY.

*How the Plague Was Fought in Manila.*—The bubonic plague is endemic in Hongkong, China, which is but two days' voyage from Manila. Hence the plague is a perpetual menace to the Philippine Islands, where it first appeared in 1899. As the infection steadily spread for two years, measures had to be taken for its suppression. The most strenuous efforts at improving the sanitary condition of the city were nullified by the filthy habits of the lower classes. As the activity of the rat in the distribution of the plague was well known, a special force of rat-catchers with distinguishing uniform was organized to work in coöperation with sanitary agents and the police. Hundreds of thousands of rats were destroyed by poison and some 60,000 were caught. As fast as caught they were tagged with the street and number where taken, and turned over to the bacteriologists for a *post mortem* examination for the plague bacillus. In this manner it was ascertained not only to what extent the disease had extended among the rats, but also in what portions of the city it was most virulent. During the first two weeks of the examination 1.8 per cent of the rats revealed the existence of the disease, and the percentage increased steadily up to 2.3. The buildings in which infected rats were found were disinfected when possible, and burned otherwise. A special plague hospital was improvised with accommodations for 1,500 patients. After the practical extermination of the rats, the immunization of the susceptible natives was undertaken, over 25,000 being inoculated with the Shiga antipestic vaccine. The success attending this means of checking the spread of the plague was perfect. The plague was as effectually driven out of the Philippine Islands as the yellow fever out of Cuba.

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*Good Housekeeping* for March prints an excellent article (condensed from the *Yale Medical Record*) by Dr. Frank Hallock on "American Intensity as Shown in the Diet." His observations are eminently sensible and serviceable, and would make a fine "lesson" for the physiology class. We have room to quote only a few words on "b'gotry in tastes":

"Unless attention is called to it comparatively few people seem to appreciate that the taste, like the other senses, is capable of development and cultivation. The habit of being intense is noticeable in the limitations of taste exhibited by many people. Thus, in a large number of American families it is positively painful to witness the expressions of extreme fondness or extreme dislike for this or that article of food. Ridiculous as it may seem, men and women go through life totally unable to enjoy and derive benefit from a variety of wholesome foods. The dislike has been formed in youth and they have never taken pains to enlarge their sense-generosity and learned to eat the given article. . . . In my

experience the bigotry in religion is quite a feeble affair compared to the bigotry in tastes and foods. If one has an optimistic faith it seems almost criminal not to teach children to like everything that mankind has proved to be desirable as food."

Everyone should read the article in the April *Century Magazine* on "Protozoa and Disease," by Dr. Gary N. Calkins, of the Department of Biology in Columbia University. Dr. Calkins is a specialist in the study of the protozoa and he writes a most readable paper, singularly free from those inaccuracies that often abound in popular expositions of scientific subjects. Our present knowledge of the causes of malaria, smallpox and scarlet fever is clearly and accurately stated.

*Why Does Not the Stomach Digest Itself?*—The solution of this puzzle and the equally pertinent question, "Why is not a tape-worm digested in the intestines?" is given in *Merck's Archives*. "A brilliant young physiologist, Weinland, of Munich, as the result of numerous painstaking experiments with the tape-worm, has apparently solved the entire riddle of the non-self-digestibility of the intestinal canal. It is all due to the presence of certain anti-bodies (anti-substances), analogous to the antilynsins and antitoxins with which Ehrlich's great studies have made us familiar. He isolated from the tape-worm an antitrypsin or anti-ferment, which when added to a mixture of fibrin and pancreatic juice prevented the digestion of the former. He similarly demonstrated the presence of an antipepsin in the secreting cells of the stomach, and of an antitrypsin in those of the intestines. These anti-ferments neutralize the action of the digestive ferments and prevent their destructive action on the respective tissues of the stomach and intestines. It may be added that those antibodies or anti-ferments are not hypothetical substances, but have been successfully isolated by Weinland."—*Dietetic and Hygienic Gazette*.

*A Fruitful Cause of Pneumonia*.—A new York physician asserted, at a meeting of a medical society recently, that steam heat is the underlying cause of the pneumonia epidemic which has scourged the metropolis this winter. Steam heat is superheat of excessive dryness. It is heat unaccompanied with a renewal of the air in the apartment heated. It produces an irritation of the respiratory tract, induces perspiration and otherwise places the individual in an absolutely receptive condition for the lodgment of pneumonia germs. It is to be noted that pneumonia claims few victims among women. Most women pass the day in houses heated by furnaces, or, if they do live in steam-heated flats, they are not "in and out" like business men, encountering severe changes of temperature a dozen times a day. The average steam-heated room is merely a superheated box in which the occupants breathe the same air over and over again. So long as this is true the indictment of steam heat as a pneumonia breeder will continue in force and effect.—*American Medicine*.

*Hygiene of the Japanese.*—The *British Medical Journal* says that the Japanese themselves attribute their high average of physical strength to a plain and frugal diet, and the system of gymnastics called jiu-jitsu, which includes a knowledge of anatomy and of the external and internal uses of water. Although during the period of their ascendancy the Samurai kept the secret that their great physical superiority was due in a great measure to the internal and external use of water, the belief that if used liberally and intelligently water is an infallible weapon against disease is now generally held. By those who go in for jiu-jitsu an average of one gallon a day is drunk. It is noteworthy that rheumatism is almost unknown in Japan; it is probable that the absence of meat from the diet, combined with the use of plenty of water, accounts for this immunity. Bathing is indulged in frequently, even by the poorest. In the matter of diet they are frugal to a degree, rice being the staple food in every Japanese house, and appearing at every meal. Japanese troops have often made record marches on a diet consisting solely of a little rice. The Japanese appreciate above all things the value of fresh air; night and day they keep their windows open and their rooms ventilated, and they do not fear draughts or damp air. Breathing exercises are an important part of their physical training—deep, careful breathing, which is only acquired by practice.—*American Medicine*.

F. B. B.

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## Reports of Meetings.

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### ONTARIO EDUCATIONAL ASSOCIATION.

The forty-third annual meeting of the association was held in Toronto on April 5, 6 and 7, in University College. About eight hundred members registered with the secretaries of the various departments. The chief interest in the proceedings centered in the discussion of the report of the committee of nineteen appointed last year to draft an improved arrangement of public and high school courses and organization. The chief features of the recommended changes are a greatly extended application of the observational principle and a decided reduction of the amount of Latin, French and German required for teachers' certificates. The extension of nature study and art subjects to all grades of the public schools marks a decided step in advance, and will eventually improve the science work of the high school. An attempt has been made to furnish the pupil with a training that will more perfectly fit him for taking his place in the battle of life.

It is to be hoped that the education department of Ontario will soon take steps to put into effect the proposed changes.

In the natural science section the election of officers resulted as follows: Honorary President, Prof. T. L. Walker, Toronto; president, T. H. Lennox, B. A., Stratford; vice-president, S. B. McCready, B. A., London; secretary-treasurer, E. L. Hill, B. A., Guelph.

The president's address dealt with the relation of natural science to the spiritual. Science is not opposed to the spiritual, but rather a help to it. Because some branches of science became prominent in an age when infidelity was prevalent, men were apt to associate infidelity with science. Upon motion the address was ordered to be printed in the proceedings of the association.

The secretary and others gave reports on some recent scientific books, mentioning among others, Professor Atkinson's book on "Mushrooms," and various nature books published by the Doubleday Company. The secretary spoke of the helpfulness of *SCHOOL SCIENCE*, and showed the practical character of the contents of the periodical, and urged the members to avail themselves of it as a reasonable means of securing the best in up-to-date scientific knowledge, especially in its relation to the teaching in secondary schools.

The closing session of the science section was a joint meeting with the mathematical and physical sections. The sections united to hear a most interesting program. Dr. F. J. Smale read a paper on "Applied Chemistry in Secondary Schools," in which he pointed out some of the demands of the modern manufacturer as regards chemical knowledge. He pointed out the immense usefulness of chemistry as a help in making all phases of manufacturing economical. As regards the high school, however, the attempt to specialize chemical teaching in high schools so as to have reference to the needs of any particular class of interest in the community, would not only impose unjust limitations upon the science itself, but would be a travesty of the purpose and ideals of secondary education.

Prof. N. R. Carmichael, of Queen's University, Kingston, read a practical paper on "The Purpose of Experiments in Teaching Physics." The writer called attention to some of the limitations to be expected in physical experiments in the high school, and showed what should be sought by teacher and pupil. He urged the faithful use of a given piece of apparatus, and the necessity of insisting upon the pupil producing the best results to be obtained from his apparatus. This was more important than trying to secure the same results that other men had secured with finer apparatus.

Dr. J. C. McLennan gave a demonstration on "Radium and Radio-Activity." This was a highly interesting address accompanied by experiments, many of them original, showing the properties of radium and its emanations.

Reported by E. L. HILL.

## EASTERN ASSOCIATION OF PHYSICS TEACHERS.

The thirty-eighth meeting was held at Newtonville, Mass., March 19, 1904. Professor W. S. Stratton, director of the Bureau of Standards, Washington, D. C., was the guest and delivered two addresses. In the morning he gave an account of the metric system, discussing the subject mainly from the historical standpoint, though several industrial applications were considered, especially in the discussion.

Immediately after the recess for luncheon the annual election of officers took place, resulting in the following choice:

President, George A. Cowen; vice-president, Irving O. Palmer; secretary, Fred R. Miller; treasurer, Arthur H. Berry; additional members of the executive committee, Fred C. Adams, N. Henry Black, Clarence Bolyston.

A committee, consisting of Messrs. Fisher, Palmer and Newell, was appointed to investigate the teaching of the metric system in the graded schools.

Mr. Gilley, for the committee on new apparatus, showed a new form of syphon barometer called the Doppel barometer or contra barometer. It differs from the ordinary barometer in that the syphon end, which is usually an open bulb, continues up above the bulb as a tube of small diameter and about 80 cm. long, filled with colored liquid from the level of the mercury in the syphon bulb to a height of about 70 cm. As the barometer falls, the level in the syphon rises, causing the colored liquid in the small tube to rise much faster than the mercury in the large tube falls.

This instrument was invented by Professor A. Böttcher, director of the Grossherzoglich Sächsische Fachschule und Lehrwerkstatt für Glasinstrumentenmacher und Mechaniker. Price, about \$6.

Another form of barometer shown by Mr. Gilley is the constant zero point barometer, made by A. Haak, Institut zur Anfertigung Wissenschaftlicher Glas-Präzisions-Instrumente und Apparate, Jena in Thuringia. Price, about \$10.

This barometer has a large tube, large space at the top and a glass vernier. There are two mercury reservoirs, to the lower of which a rubber bulb is attached. Pressing this bulb forces mercury from the lower reservoir through a glass tube which extends up through the mercury in the upper reservoir. The top of this tube is the zero level. When the barometer falls the excess of mercury drops through the overflow tube into the lower reservoir, thus keeping the zero point constant. When the barometer rises enough mercury is forced up by the rubber bulb to cause the overflow to begin.

Mr. Gilley also showed a Boyler tube, made by Newton & Co., 3 Fleet street, London. This tube is about 6 cm. long, partly filled with some liquid unknown, hooked at the end. When suspended in the lantern and

heated it gave a remarkable demonstration of sudden change from liquid to vapor when surface tension was overcome, followed by as sudden condensation soon after the removal of the heat.

The afternoon address by Professor Stratton was on "The Equipment of Physical Laboratory Workshops." He provided an outline of the necessary tools and machines, together with the names and addresses of reliable firms dealing in the special piece of apparatus. The following books and periodicals were suggested as helpful adjuncts:

*Machinery*, shop edition, 66 West Broadway, New York.

*American Machinist*, World building, New York.

*Power*, World building, New York.

*Iron Age*, 66 West Broadway, New York.

*Electrical World and Engineer*, 114 Liberty street, New York.

*Western Electrician*, etc., Chicago.

*Electrical Review*, 13 Park Row, New York.

*Ice and Refrigeration*, 177 La Salle street, Chicago.

*Engineering Record*, 114 Liberty street, New York.

"Shop Kinks," Robert Grimshaw; 400 pages; \$2.50.

"Mechanical Movement, Devices and Apparatus," Hiscox; 400 pages; \$3.00.

"A Handbook on Japanning and Enameling," William N. Brown; 52 pages; 2s 6d.

"Burnishing, Lacquering, Etc.," William N. Brown; 35 pages; 2s 6d.

"The Art of Patternmaking," I. McKim Chase; \$2.50.

"Laboratory Arts," Threefall.

"Modern Machine Shop Practice," J. Rose.

"Glass Blowing," Shenstone.

Professor Stratton is so firm in his belief in the workshop that if the amount to be expended in fitting up a department were only \$500 he would put half of it into shop and tools. He believes also that every physical laboratory of size should have as an assistant a mechanician, who is a graduate of a training school at least, to be paid \$50 to \$60 per month and to work Saturdays also.

Reported by LYMAN C. NEWELL.

#### NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

The nineteenth meeting was held in Boston, February 20, 1904. The morning was devoted to inspecting the laboratories of the State Board of Health, and in the afternoon the members listened to an address on "Air, Water and Food in the High School Course of Study," by Mrs. Ellen H. Richards, of the Massachusetts Institute of Technology.

An account of the Board of Health laboratories and the methods used there will be found in another part of this number of SCHOOL SCIENCE.

The following were elected to membership: Augustus Klock, Concord, Mass.; A. R. Lincoln, Springfield, Mass.; A. G. MacGregory, Brockton,

Mass.; Miss Grace MacLeod, Springfield, Mass.; Edgar P. Neal, West Boylston, Mass.; F. H. Cowan, Augusta, Me.; Miss Caroline I. Doane, Southington, Conn.; Miss Mary E. Gould, Dedham, Mass.; Miss Mary E. Holmes and Miss Caroline S. Moore, South Hadley, Mass.

The committee on current events presented an elaborate report, which was printed in *SCHOOL SCIENCE* for May, 1904. The committee on new apparatus showed (1) the "Johnson Accident Case," a sort of emergency box containing bandages, cotton, plaster, soap, etc.; (2) a small electric furnace known as the Custer oven; attention was also called to the directions for making a similar furnace, published in *Dental Cosmos*, January, 1903.

Mrs. Richards, who believes thoroughly in practical education, said in part:

"The high school is held to mark a stage in the evolution of the individual by education. In the elementary school we teach habits because they are right, according to experience. Why must I not drink ice water or sit in a draught? Why must I not eat all the candy I want? Scores have tried it with disastrous results, we reply. Now and then one escapes. So in the early school years we try to have the imitative faculty keep the little ones straight by preparing the right things for them to eat and the best air for them to breathe, and facilities for cleanliness and a teacher who sets a good example.

"But upon reaching the high school a new phase is entered upon. The younger generation thinks itself wiser than the older; it is not content to be told that a given way is best; it must try its own way. The pupil at this age sets out to test all things and to draw his own conclusions. He can no longer be corralled. He will take wide sweeps of discovery. Therefore it is wise to make certain places in the surrounding fence easy to break down, even to put a tempting bait outside, so that he may *learn by doing; find out by trying*. Allow him the pleasure of taking home a new and practical idea. But all the while we must so arrange matters that the young person is getting useful experience without his realizing *how useful* it may be. We must plan even his play so that the time he spends will tell on his future well being.

"We may often appeal to this young person on his most vulnerable point. Suppose the chemistry teacher says to his class the first day: 'This week we will study candy.' Eyes bright, ears alert, smiles all over the room!

"First, how is candy made? Let each pupil write in 100 words what he can learn. Then, when the stuff of which it is made is run down to sugar, the composition of sugar may be given and the gases, hydrogen and oxygen, and the black, solid carbon illustrated. And right there, before going any deeper into chemistry, the essentials of combustion, of animal heat, of food as an essential of life because life must mean heat, of products

of combustion to be gotten rid of in stoves and chimneys; all the usual instruction in the laws of gases, of chemical combustion, may be grouped about these simple facts.

"How does sugar get to the cells to be burned? By water, and plenty of it. We may show in osmosis that only *dilute* sugar solutions will go through the membranes and then we may illustrate by the amount of water required to circulate a pound of candy to the best advantage; assuming a 1 per cent solution of sugar to circulate most freely, a simple calculation shows that three ounces of sugar is a fair average allowance per day.

"Sugar leads easily and naturally to milk, sugar and to the cream and butter composed of the same things and performing the same office in general, but capable of being stored against a time of need when mother forgets to put up a lunch or when it is zero weather and the furnace can not be run hard enough or fast enough to keep the body warm.

"Set the scouts to find how many things they had to eat during the day, besides milk, which had fat in them. If we may have three ounces of sugar, how much fat? Fat is worth about twice as much as an energy giver, and if it is to be partly stored, if not needed, it is fair to assume that about the same quantity as of sugar will serve. It does not dissolve in water like sugar and so does not warm the body up so quickly, and it does not *ferment* if an excess is taken.

"But cheese is made from milk, and therefore there must be something else in milk besides sugar and fat. There is no need to develop the idea further. The nitrogen-containing foods, the danger of toxins, the care with which one must keep such things out of contact with the air and in the cold and many other useful and scientific facts may be strung on this chain—as much of the chemistry of nitrogenous compounds as is best, nitrous acid, nitric acid, nitrates, ammonia, etc.—and that will bring the class to the principle of the Kjeldahl determination of nitrogen by a miniature apparatus illustrating the principle. If pure reagents are at hand, then sugar gives no ammonia; wheat, beans and other foods show much. The class may try each one and so learn how we know these facts.

"Teach them to take on trust the work done for them by the United States Department of Agriculture and to use the knowledge so carefully gained by experts.

"This leads naturally to human food, dietaries, food composition. Pupils may make charts, collect museums and gradually accumulate a fund of knowledge which will be of great benefit in after life.

"In considering air, the subject of dust may be introduced by calling attention to the collection of it by the exposure of candy and fruit in open stalls on the street, the leaving of cooked foods exposed in

dusty rooms. 'Dust gardens' may be the simple means of much sound hygienic teaching and may be used to counteract newspaper exaggerations.

"To make a 'dust garden' the media or 'soil' for the bacteria is first melted by placing the bottle in a beaker containing hot water. The media is then quickly poured into the dish and the cover put on. As soon as the media has hardened (a few minutes only are required) it is ready for use. The process is started by simply removing the cover and exposing the media to the air to fifteen minutes; or the finger may be touched to any desired object, an old bill, perhaps, and then gently pressed to the surface of the media. Within a period varying from twelve to thirty-six hours the eye should be able to detect the starting of the tiny colonies of bacteria, if the inoculation has been successful. A media, specially prepared for this purpose, may be procured of Mr. Simeon C. Keith, 394 Rutherford avenue, Charlestown, Mass., at 25 cents per bottle. The glass dishes, with covers, Mr. Keith also furnishes, if desired, at 35 cents each.

"An excellent little book, whose scope is explained by its title, is 'Chemistry of Plant and Animal Life,' by H. Snyder, published by Macmillan. A list of other references, bearing upon the subject of Mrs. Richards' lecture, follows:

"Food and the Principles of Dietetics," by Robert Hutchinson. (William Wood & Co., New York.)

"The Cost of Food," by E. H. Richards. (John Wiley & Sons, New York.)

"Diet and Food," by Alexander Haig. (J. & A. Churchill, London.)

"Air, Water and Food," by Richards and Woodman. (J. Wiley & Sons.)

"Muscle, Brain and Diet," by E. H. Miles; second edition, 1900. (Macmillan, London.)

"Home Sanitation," by Richards and Talbot. (Home Science Publishing Company.)

"School Sanitation and Decoration," by Burrage and Bailey. (D. C. Heath & Co., Boston.)

"Guidebook to Hygienic Diet," by Sidney H. Beard. (Thomas Y. Crowell & Co., New York.)

"The Dietary," by E. Huntington. (26 Charter Oak place, Hartford, Conn.; 15 cents.)

"The Pleasures of the Table," by George H. Ellwanger. (Doubleday, Page & Co., New York.)

Government Bulletins: United States Department of Agriculture, Nos. 63, 69, 89, 109, 98, 126 and 129. Farmers' Bulletins, Nos. 34, 74, 85, 93 and 142.

Reported by L.

